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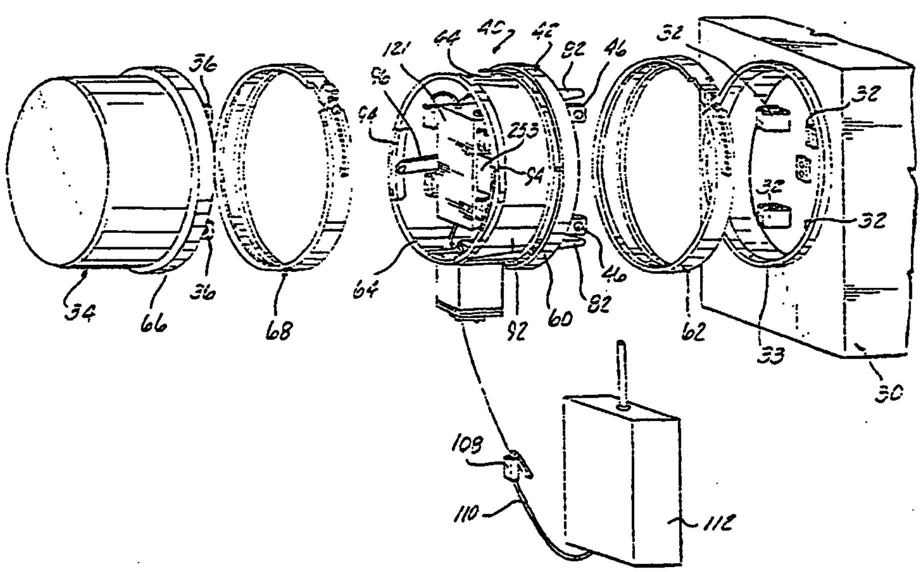

(57) Abstract

Instantaneous current and voltage values are digitized at each of a plurality of electrical utility customer sites (18) and integrated by a processor to calculate electrical power consumed at each customer site (18). A communication interface couples the processor at each customer site (18) to a central processor (12) in a central utility site to communicate the power consumed values of each customer site (18) to the central utility site (10). In a preferred emdodiment, the automatic meter reader apparatus is mounted in an electrical watthour meter socket adapter (40) which plugs into a watthour meter socket (30) at each customer site (18). Telephone modem circuitry mounted in the socket adapter connects to telephone lines to communicate calculated power values from each customer site (18) to the central utility site (10).

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REMOTE AUTOMATIC METER READING APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention:

The present invention relates, in general, to automatic watthour meter reading apparatus and, specifically, to remote automatic watthour meter reading apparatus.

Description of the Art:

The advantages of automatic reading of electrical watthour meters and other utility meters have long been recognized. Such advantages accrue from the elimination of the high costs associated with manually reading meters located a long distance from a central utility office, inside of a customer's premises, at dangerous locations, and at the remote ends of a distribution network. Further, in rural utility networks, long distances are typically encountered between each meter location. Thus, more employees are required to manually read each meter on a predetermined time schedule for accurate billing.

However, such advantages have not been fully attained by previously devised automatic meter reading apparatus for several reasons. Most automatic meter reading apparatus require a specially designed watthour meter containing the telephone communications circuit, the power measuring circuitry and the data accumulation circuitry. In a typical electrical utility having tens to hundreds of thousands of electrical meters, the capital cost of replacing all watthour meters with specially designed automatic reading watthour meters is extremely high. Further, a single utility system typically uses several different types of watthour meters. Converting such meters in all locations to automatic reading meters is impractical since it would require several different types of automatic meter reading apparatus thereby increasing inventory and complicating ordering, installation and service of the meters. Previously devised automatic meter

reading apparatus have also had a high cost compared to conventional,single phase, mechanical rotating ring-type counter meters and have other disadvantages which have limited their widespread application.

In the context of providing an economical, easily installed, widely usable automatic meter reading apparatus for watthour meters, another factor which must be addressed is accuracy in measuring power usage. The accuracy standard for automatic meter reading apparatus is the ±2% accuracy of conventional mechanical watthour meters. Some automatic meter reading devices sense rotation of the mechanical rotating ring in a conventional watthour meter and convert the sensed rotations to digital signals corresponding to indicated power usage. Thus, such automatic meter reading devices are limited to the accuracy of the mechanical watthour meter. Electronic sensing of current and voltage for the calculation of power has also been proposed for electronic watthour meters. Such sensing circuits have been specifically designed for use in a specially designed electronic watthour meter. However, little attention has been paid in such single phase watthour meters for accurately measuring power consumption.

Another disadvantage of previously devised automatic meter reading devices utilizing conventional telephone lines has been the inclusion of complex telephone dialing, call-back and reporting circuits to coordinate the flow of power usage information between each remote watthour meter site and the central utility office. This has increased the cost of automatic meter reading devices beyond the point of widespread economical implementation. Further, the use of dedicated telephone lines which do not interfere with a customer's telephone usage has also been proposed along with the attendant cost of running additional telephone lines to each customer site.

Another factor which has not been fully addressed by previously devised automatic meter reading devices is the desirability of having time of day and demand power

control by the utility company at r sidential locations. The increased cost of generating electricity has required other billing approaches by utilities including time of day billing where varying rates are applied to electrical usage at different periods during each 24 hour day. Another billing approach is demand or peak billing where the amount of power consumed is billed at a higher rate for power usage exceeding a predetermined amount. In order to implement such alternate billing approaches, it is necessary for the utility company to have accurate power consumption data, such as having the ability to determine the peak load of any customer and the power usage during any time period during the day.

Thus, it would be desirable to provide an automatic meter reading device for watthour meters which overcomes the problems of previously devised automatic meter reading devices. It would also be desirable to provide an automatic meter reading device which is usable with conventional watthour meters without requiring modifications to such watthour meters or the meter socket. It would also be desirable to provide an automatic meter reading device for watthour meters which utilizes data communication via conventional telephone lines with a central utility site. It would also be desirable to provide an automatic meter reading device for watthour meters which is usable with most of the many different types of watthour meters currently used by utility companies.

SUMMARY OF THE INVENTION

The present invention is a remote automatic meter reading apparatus which is capable of sensing, calculating and storing power consumption values at a plurality of electrical utility customer sites and communicating such power consumption values via a communication interface to a central utility site.

Generally, the automatic meter reading apparatus of the present inv ntion includes a central processing

means, disposed at the central utility site, which executes a stored program to interrogate automatic meter reading equipment at each of a plurality of remotely located utility customer sites and to receive, process and store power consumption values communicated from each remote customer site. A communication interface means communicates data signals between the central utility site and each of the remote customer sites. The communication interface may comprise conventional telephone conductors with modems employed at the central utility site and each remote customer site.

Current sense means are coupled to the electrical power conductors at each customer site for sensing the instantaneous current of the electrical load at each customer site. Voltage sense means are also coupled to the electrical power conductors at each customer site for sensing the instantaneous voltage at each customer site. The current and voltage values are digitized in an analog to digital converter in the remote automatic meter reader apparatus at each customer site under the control of a processor means which executes a stored program and integrates the sensed and digitized instantaneous current and voltage values over time to generate power consumption values in kilowatt hours and/or KVA which are stored in a memory in the remote automatic meter reader apparatus at each customer site.

A communication protocol established by the control program executed by the central processor means at the central utility site interrogates the processor means at each customer site on a predetermined time basis to receive the calculated power consumption values therefrom for use in customer billing and for other purposes. Additionally, low voltage and high voltage limits can be programmed into the automatic meter reading apparatus at each customer sit from the central utility to insure compliance with applicable regulatory rules.

In a preferred embodim nt, the remote automatic meter reading apparatus at each customer site is mounted in an electrical watthour meter socket adapter which plugs into the standard watthour meter socket at each customer site and which may receive a conventional watthour meter therein. In the preferred embodiment, the current sense means comprises coils disposed about the blade terminals in the socket adapter which are connected to the electrical power conductors when the socket adapter is plugged into the watthour meter socket. The voltage sense means comprises amplifiers connected to the electrical load terminals in the socket adapter which sense the instantaneous voltage at each customer site. The processor means, associated memory, communication interface, analog to digital conversion, and power supply are also mounted in the socket adapter.

A power outage monitoring program is stored in memory in each remote automatic meter reading unit and senses, totals and stores information for monitoring the frequency and duration of power outages at the associated customer site. This power outage information is reportable to the central utility site on demand and/or along with the transmission of power consumption data to the central utility site.

The automatic meter reading apparatus of the present invention enables remote automatic meter reading capabilities to be coupled with a conventional watthour meter without requiring any modification to the conventional watthour meter or watthour meter sockets. The automatic meter reading apparatus of the present invention is mountable in a watthour meter socket adapter so as to be easily employed at each remote customer site.

BRIEF DESCRIPTION OF THE DRAWING

The various features, advantages and other uses of the present invention will become more apparent by referring to the following detailed description and drawing in which:

Figure 1 is a schematic diagram of an automatic watthour meter remote reader apparatus according to the present invention;

Figure 2 is an exploded, perspective view showing the mounting of a watthour meter and a socket adapter having automatic meter reading circuitry of the present invention contained therein in a conventional watthour meter socket;

Figure 3 is a front elevational view of the socket adapter shown in Figure 2;

Figure 4 is an exploded, perspective view showing the base and shell portions of the socket adapter shown in Figure 2;

Figure 5 is a block diagram of the automatic meter reader circuitry mounted in the socket adapter shown in Figure 2;

Figure 6 is a detailed schematic diagram of the power supply shown in Figure 5;

Figure 7 is a detailed schematic diagram of the voltage and current sensing, and the analog to digital signal conversion circuits shown in Figure 5;

Figures 8A, 8B and 8C are detailed schematic diagrams of the microcontroller and memory circuits shown generally in Figure 5; and

Figure 9 is a detailed schematic diagram of the telephone modem shown generally in Figure 5;

Figures 10 and 11 are flow diagrams of the software control program controlling the operation of the remote automatic meter reading apparatus;

Figure 12 is an exploded, perspective view of the telephone line connector enclosure;

Figure 13 is a perspective view of an optional cover and display;

Figure 14 is a cross sectional view generally taken along line 14-14 in Figure 13;

Figure 15 is a cross s ctional view generally taken along line 15-15 in Figure 3; and

Figures 16-20 are pictorial representations of menu screens depicting the modes of operation of the control program of the central processing unit.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawing, there is depicted an automatic meter reader apparatus particularly suited for automatic reading of electrical watthour meters located remotely from a central utility site or office.

Central Utility

As shown in Figure 1, a central utility company site is depicted generally by reference number 10. The central utility site 10 may be the central business office of the utility, a generating station, etc., where billing information is accumulated, tabulated and recorded. A central processing unit 12 is located at the site 10. The central processing unit 12 may be any suitable computer, such as a mainframe, a PC, a PC network, workstation, etc., having the capacity of handling all of the utility company customer billing transactions as well as the remote data communications, as described hereafter. For example, a 386 based PC may be employed. The central processing unit 12 communicates with a memory 14 which stores data specific to each utility customer, as well as other data regarding power usage of each customer. The memory 14 comprises both hard disc storage memory and on board volatile memory. Although high voltage, electrical power distribution lines denoted generally by reference number 16 for a three-wire, single-phase electrical system, are shown as extending from the central utility site 10 to each utility customer denoted generally by reference number 18, it will be understood that the electrical power distribution lines 16 may extend from a separate electrical power generating site through electrical transmission lines with appropriate voltage transformations, and not directly from the central utility site 10. Further, it will be understood that the electrical power distributi n lines 16 may provide three-phase power to each customer site 18.

As shown in Figure 1, various input and output devices, such a keyboard, printer(s) 13, display terminals or monitors 15, etc., may also be connected to the central processing unit 12 as is conventionally known. In addition, one or more modems 20 are connected to the central processing unit 12 at the central utility site 10 and to conventional telephone wiring circuits denoted generally by reference number 22 which extend to each utility customer site 18. The number of modems 20 matches the number of telephone lines between the central site 10 and all of the customer sites 18. Each modem is capable of handling a large number of remote customer units 18, such as, for example, 2880 remote customer units 18, based on the assumption that a telephone call to a remote unit 18 is made every five minutes during a twelve hour period each day and for only the approximate twenty days per monthly billing period. The telephone wiring circuits 22 may be conventional telephone wires, as well as fiber optics, satellite, microwave or cellular telephone communication systems. The modem 20, which may be any conventional modem, functions in a known manner to communicate data between the central processing unit 12 and each utility customer site 18, as described in greater detail hereafter.

Also stored in the memory 14 are the various software control programs used by the central processing unit 12 to automatically communicate with the electrical watthour meter at each utility customer site 18 as described hereafter. The memory 14 also stores the power usage data for each utility customer as well as various billing routines utilized by a particular utility company.

Generally, the software control program stored in the memory 14 is a menu driven database capable of handling multiple simultaneous calls to a number of remote automatic meter reader circuits. The control program stores each customer's power usage in accumulated KWH and KVA, and instantaneous voltage, current and power factor

measurements. Also, the control program generat s an end-of-day summary printout through a printer 13.

The control program also enables a utility employee to remotely program each automatic meter reading circuit at the central site 10. Such programmable features include time, date and year data, a multi-level security code for communication access, receive call and originate call modes, line voltage quality set points, start and end times for multiple demand billing period intervals, i.e., three intervals in each 24 hour period, the date, time and duration of a communication window for communication with the central site 10, and the date and on or off conditions of a relay at the remote site 18.

Figure 16 depicts the main system menu which appears on the monitor 15 at the central site 10. The main system menu provides various options which may be selected by the user to monitor incoming calls from the remote AMR units, to call a specific remote unit, to review the records of any remote unit, to review a remote unit setup, to utilize system maintenance or a general help selection.

Figure 17 depicts a menu screen which is generated when the first option in the main system menu entitled "monitor incoming calls" is selected. As shown in Figure 17, two remote AMR units are currently calling or are about to call the central processing unit for the transmission of data to the central site. The telephone number and identification number of each remote AMR unit currently transmitting data to or about to transmit data to the central site are depicted on the screen shown in Figure 17.

Figure 18 depicts a screen on the monitor 15 at the central site when option 2 in the main menu is selected to call a specific remote AMR unit. This screen is preceded by another screen, not shown, which requires the user to enter his or her pass c d and then the specific identification number f the remote AMR unit to be called. When the correct informati n is entered, the screen shown

in Figure 18 will be displayed on the monitor 15 at the central site. If three erroneous pass codes are entered by the user, the control program of the central processing unit 12 will prevent further access to the system.

Figure 19 depicts the screen for option 3 in the main menu which enables a user at the central site 10 to view the records or data from a particular remote AMR unit. The instantaneous voltage and current readings on each of the incoming power line conductors at the time of the call to the selected remote AMR unit are displayed on the screen. Also, the maximum and minimum voltage on the line conductors, the number and duration of outages as well as accumulated KWH, KVAR and power factor (PF) since the last reading are depicted. Total KWH, KVAR and power factor readings to date are also shown as well as total power outages and power outage durations.

Finally, Figure 20 depicts a screen when option 4 on the main system menu is selected to view a remote AMR unit setup. All of the programmable information of a particular selected remote AMR is displayed in the screen shown in Figure 20. This information includes the day, time in hours, minutes and seconds and the window duration of the primary data communication window to the selected AMR unit. The first and second alternate data communication windows and their duration are also shown. Power demand settings for a particular unit, if employed, are also depicted on the screen. Any of these values may be programmed into a specific remote AMR unit from the central site.

At appropriate times, as determined by the utility company, the power consumption data from each remote AMR unit can be input to a suitable billing software program to generate bills for each customer. By way of example only, the power consumption values transmitted from each AMR unit t the central site, as described above, can be stored in a hard disk which can then be transferred to

a separate billing computer system at the utility company to generate customer bills.

Remote Utility Customer

As shown in Figures 1 and 2, a plurality, such as tens or even hundreds or thousands of utility customer sites 18 are connected to the electrical power distribution network 16 at remote locations of varying distances from the central utility company site 10.

As is conventional, each utility customer site 18, as shown in Figure 1, includes a utility meter socket 30 having a plurality of internally mounted jaw terminals 32 which are connected to the single-phase three-wire line conductors of the electrical distribution network 16. Although not shown in Figure 1, separate jaw terminals are provided in the socket 30 and connected to the individual service or load conductors at each utility customer site 18. In a conventional usage, the socket 30 is mounted at a suitable location at the utility customer site 18, such as on an exterior wall, with the load conductors extending from the socket 30 to the building wiring circuits.

A conventional electrical watthour meter 34 for recording electrical power usage at a particular customer site 18 has a plurality of outwardly extending blade-type electrical terminals 36 which electrically engage the jaw contacts or terminals 32 in the socket 30. A sealing ring, depicted in Figure 2 and described in detail hereafter, is provided for sealingly attaching the watthour meter 34 to a peripheral mounting flange 33 surrounding an opening in the front cover of the socket 30 to lockingly attach the watthour meter 34 to the socket 30 and to prevent unauthorized removal or tampering therewith.

AMR Socket Adapter

As shown in Figures 1 and 2, and in greater detail in Figures 3 and 4, the automatic meter reader apparatus of the present invention, in a preferred embodiment, includes a socket adapter denoted generally by reference number 40. The s cket adapter 40 is

interconnected between the watthour meter 34 and the socket 30 in a known manner. However, according to the present invention, the socket adapter 40 includes internally mounted automatic meter reading and telephone communication circuits as described in greater detail hereafter. The use of the socket adapter 40 to house the automatic meter reading circuitry is a preferred embodiment of the present invention. It will be understood that such automatic meter reading circuitry, as described hereafter, can also be mounted at each customer site 18 by other means, such as in an enclosure separate from the watthour meter and meter socket.

In general, the watthour meter socket adapter 40 includes a two-part housing formed of a base 42 and a shell 44 which are joined together by fasteners. As described hereafter, a plurality of electrical contacts 47 are mounted in the socket adapter 40 and have a first end 46 extending outward from the base 42 for removable engagement with the jaw-type electrical contacts mounted in the watthour meter socket 30. The electrical contacts 47 are provided in the socket adapter 40 in any number, type and arrangement depending upon the electrical power requirements of a particular application. By way of example only, the electrical contacts 47 are arranged in the socket adapter 40 in a first line pair of contacts and a second load pair of contacts. Each of the contacts receives one of the blade-type electrical terminals 36 mounted on and extending outward from the watthour meter 34. Each of the contacts is preferably in the form of a pair of spring-biased fingers which are formed of an electrically conductive material. The jaws of each electrical contact in the socket adapter 40 are joined together to form a single blade-like terminal extending outward at a first end 46 from the base 42 of the socket adapter 40.

As is conventional, a peripheral flange 60 is formed on the base 42 of the socket adapter 40 which mates

with a similarly formed flange 33 on the watthour meter socket or housing 30 for mounting of the watthour meter socket adapter 40 to the watthour meter socket 30. A conventional seal or clamp ring 62, such as a seal ring disclosed in U.S. Patent No. 4,934,747, the contents of which are incorporated herein by reference, is mountable around the mating flanges 60 on the socket adapter 40 and the flange 33 on the socket 30 to lockingly attach the socket adapter 40 to the socket 30 and to prevent unauthorized removal of or tampering with the socket adapter 40.

It will also be understood that the socket adapter 40 and the socket 30 may be configured for a ringless connection. In this type of connection, not shown, the cover of the socket 30 is provided with an aperture which is disposable over the socket adapter housing and locked to the socket 30 enclosure after the socket adapter 40 has been inserted into the socket 30.

As shown in Figure 2, a second mounting flange 64 is formed at one end of the shell 44 of the socket adapter 40. The mounting flange 64 mates with a similarly configured mounting flange 66 formed on the watthour meter 34. A second sealing ring 68, which may be identical to the sealing ring 62, described above, is lockingly disposed about the mating flanges 64 and 66 to lockingly attach the watthour meter 34 to the socket adapter 40.

As shown in greater detail in Figures 4 and 15, the base 42 of the socket adapter 40 includes a central wall 70 which is integrally formed with and surrounded by an annular, peripheral side wall 72. The side wall 72 extends outward from the central wall 70 for a predetermined distance to form an internal recess or cavity in the base 42. The outer portion of the side wall 72 is configured as the rim or mounting flange 60 for mating engagement with th mounting flange 33 on the socket 30.

A plurality of mounting bosses 74 are integrally form d on the c ntral wall 70 and the side wall 72 at

prescribed locations for connecting the base 42 to the shell 44 by suitable fasteners, as described hereafter. In addition, a plurality of spaced bosses 76 are formed on and extend outward from the central wall 70. Each of the bosses 76 includes a central aperture 80. The aperture 80 is preferably in the form of a slot for receiving the blade terminals mounted in the shell 44 therethrough, with the exterior end 46 of the blade terminals extending outward from the back surface of the central wall 70 of the base 42 in the orientation shown in Figure 4.

Lastly, protective flanges 82 are formed on the back surface of the central wall 70 adjacent to each blade terminal to provide protection for the exterior end 46 of each blade terminal in a conventional manner. The base 42 and its various described elements is preferably formed as a one-piece molded member from a suitable, electrically insulating, plastic material.

Referring now to Figures 3, 4 and 15, the shell 44 of the socket adapter 40 includes a base wall 90 and an annular side wall 92 disposed at the periphery of the base wall 90 and extending away from the base wall 90 to form an interior cavity or recess within the shell 44. The outer end of the annular side wall 92 is formed with a rim or mounting flange 64 for mating engagement with the mounting flange 66 on a watthour meter 34, as shown in Figure 2 and described above.

Surge protection strips 94 are mounted on the exterior peripheral edges on opposite sides of the mounting flange 64. Electrically conductive tabs 96, only one of which is shown in Figure 4, extend from the strips 94 to the bottom wall 90.

A plurality of terminal bosses, each denoted by reference number 98, are integrally formed on and extend outward from the bottom wall 90 into the cavity formed between the bottom wall 90 and the annular side wall 92. Each of the boss s 98 includes an internal b re 100 which mountingly receives a suitable jaw-type terminal. A

plurality of apertures are formed in the bottom wall 90 and receive suitable fasteners, not shown, to attach the shell 44 to the bosses 74 in the base 42.

It will be understood that the number, position and arrangement of the bosses 98 may vary from that shown in Figures 3 and 4 to other arrangements depending upon the particular electrical power requirements at a utility customer site 18 at which the socket adapter 40 and socket 30 are employed.

A cutout or aperture 104 having an irregular shape is formed in the bottom wall 90 of the shell 44 for mounting of the automatic meter reading circuitry therethrough, partially within the interior cavity in the shell 44 and partially within the interior cavity between the bottom wall 90 of the shell 44 and the central wall of the base 42.

As shown in Figures 2, 3 and 12, a telephone line connector sleeve 106 is mounted to the annular side wall 92 of the shell 44 by suitable fasteners, not shown. The sleeve 106, in one embodiment, has a generally tubular construction with either a square, rectangular, circular, etc., cross sectional shape.

As shown in Figure 12, a metallic mounting plate 117 having a central aperture and fastener receiving apertures is mounted adjacent the flat portion formed in the bottom of the annular side wall 92 of the shell 44. A gasket 107 formed of a suitable seal material has the same configuration as the plate 117 and is sandwiched between the plate 117 and one end of the sleeve 106.

Screws extend through certain of the apertures in the annular side wall 92 of the shell 44, the plate 117, the gasket 107 and one end of the sleeve 106 to securely and sealingly attach the sleeve 106 to the annular side wall 92 of the shell 44.

A telephone connector 113 containing two female-type telephone jacks two conventional RJ11 telephone connection jacks 114A and 114B is mounted in a snap-in fit

in the upper portion of the sleeve 106. The connector extends through the gasket 107, the mounting plate 117 and the annular side wall 92 to dispose one of the connection jacks 114A within the interior of the shell 44. The telephone connection jack 114A removably receives a telephone jack 115 which is attached to telephone line conductors 116 extending to the telephone modem circuitry in the AMR. The other telephone connector 114B is adapted to removably receive a telephone jack 108 attached to one end of a telephone wire conductor 110. The telephone wire conductor 110 is connected in a known manner to a telephone junction box 112 which is typically mounted at the utility customer site 18 adjacent to the watthour meter socket 30. Conventional telephone wires extend from the junction box 112 to the telephone wire network 22, as shown in Figure 1.

The sleeve 106 is sealingly closed so as to be accessible separate from access to the interior of the socket adapter 40. A gasket 118 and a cover plate 119, each having the same configuration are attached to the opposite end of the sleeve 106 and secured thereto by means of fasteners, such as threaded studs which extend through certain apertures in the annular side wall 92 of the shell, the plate 117, the gasket 107, the sleeve 106, the gasket 118 and the cover plate 119. The exterior ends of the studs receive wing nuts 109 to securely and yet removably attach the cover plate 119 to the sleeve 106. The wing nuts 109 have apertures for receiving a conventional seal wire to provide tamper indication. A strain relief 105 is mounted in a snap-in fit in the cover plate 119 and receives the telephone conductor 110 therethrough. In this manner, the high electrical power connections within the socket adapter 40 are separate from the telephone line connections within the sleeve 106. Telephone personnel may access the sleeve 106 by removing the cover plate 119 and inserting th telephone connect r 110 and tel phone jack 108 through the strain relief 105 into connection with the telephone connector 114B mounted within the sleeve 106 to

connect the AMR to the telephone junction box 112 and the telephone wire network 22. The wing nuts 109 are then threaded onto the studs to securely retain the cover plate 119 on the sleeve 106. A seal wire, not shown, is passed through the apertures in the wing nuts 109 to indicate a sealed, non-tampered condition for the telephone sleeve 106.

It will also be understood that other types of telephone communication means, rather than hard wire conductors, may also be employed. Such communication means may include fiber optic cables as well as satellite, cellular, microwave or other telephone communication means. With such communication networks, suitable connectors will be provided in the sleeve 106 attached to the shell 44 to provide electrical data communications between the automatic meter reader circuitry mounted within the socket adapter 40 and the telephone communication network to provide data communications between the automatic meter reader circuitry at each utility customer site 18 and the central utility site 10, as shown in Figure 1.

AMR Circuitry

A general block diagram of the major components of the automatic meter reader (AMR) circuitry denoted generally by reference number 120 which is mounted in each socket adapter 40 at each utility customer site 18 is shown in Figure 5. The automatic meter reader circuit 120 includes a power supply 122, voltage and current sensing, analog to digital conversion circuits 124, a central processing unit and associated logic 126, a memory 128, a telephone communication modem 130, an opto-communication port 254, a RAM clock 230, an auto-tampering switch 250 and a form C relay control 252 with associated solid state switch. The details of each of these major components will now be described with reference to Figures 5-9.

As shown in Figures 3, 4 and 15, the AMR circuitry is mounted within a housing 121 having a shape sized to fit within th opening 104 in the bottom wall 90

of the shell 44. By way of example only, the housing 121 generally has a cubical rectangular shape. A threaded stud 123 extends outward from the back wall of the housing 121 and extends through an aperture formed in the central wall 70 of the base 42 where it is attached by a suitable nut to retain the housing 121 in a fixed relationship within the base 42. The housing 121 is provided with a back wall, side walls and a removable cover. The cover is removable to enable access to the components of the AMR circuitry mounted therein. As shown in Figure 4, grommets 125 are mounted on the top and bottom and provide a sealed connection for various electrical conductors extending from the AMR circuitry exteriorly of the housing 121.

The housing 121 is preferably formed of a suitable metal so as to provide an electric shield for the AMR circuitry mounted therein. Alternately, the housing 121 may be formed of a plastic, such as an injection molded plastic, with a thin metal coating sprayed or otherwise formed on the interior surface thereof to form the electrical shield.

As is conventional, the electrical power distribution network 16 from the central utility company generating site typically carries 240 VAC at a residential or commercial level. A single-phase, three-wire power distribution network 16 is shown in Figures 1, 5 and 6 with three wires connected to the electrical power distribution network 16 at each utility customer site 18, as shown generally by reference number 132. Each line 134 and 136 carries 120 VAC RMS with respect to neutral or ground wire 138 ±30% at 60 Hz. The customer conductors 132 are connected through the appropriate line contacts and terminals in the socket 30 and the socket adapter 40 to the power supply 122 of the automatic meter reader circuitry 120. The general function of the power supply 122 is to provide regulated, 1 w level DC power at the preferred ±DC levels required by the electronic components used in the automatic meter reader circuit 120.

The power supply 122 includ s an electromagnetic interference filter 140 formed of common mode inductors 142 and 143, noise capacitors denoted generally by reference numbers 144, 145 and 146, metal oxide varistors V2 and V3, and de-coupling capacitors 147 and 148. A rectifier/filter circuit 149 is connected to the filter 140. The rectifier/filter circuit 149 includes a full-wave, diode bridge rectifier 150, voltage doubler capacitors 151 and 152 and a filter capacitor 153, which are connected as shown in Figure 6. The rectifier/filter circuit 148 and the de-coupler capacitors 147 and 148 of the filter circuit 140 are connected to a flyback converter circuit 154 which converts the output of the diode bridge rectifier 150 to a precise +5 VDC power output, labelled "VCC". The flyback converter circuit 154 is conventionally constructed and includes a flyback transformer 155 and a power switching regulator 156, Model No. PWR-SMP210BN1 sold by Power Integration Company. Various capacitors, resistors and diodes are interconnected in a conventional manner in the flyback converter circuit 154 to provide the desired output voltage.

As also shown in Figure 6, the power supply 122 includes a boost circuit 160 for boosting the +5 VDC output from the flyback converter 154 to the +12 VDC for use with the various operational amplifiers employed in the automatic meter reader circuit 120. The boost circuit 160 includes boost inductors 162 and 164 as well as a boost regulator controller 166, such as a boost regulator controller Model No. MAX743EPE made by Maxim.

The AMR circuit 120 also includes a voltage sensing network denoted in general by reference number 180 in Figure 7. The voltage sensing network receives 120 VAC RMS 60 Hz input from the utility lead lines 132. One set of voltage inputs including voltage lead line connections 182 and 183 are between one lead lin and neutral; while the other pair of inputs 184 and 183 is between the other lead line conduct r and neutral. The voltage lead

connections are provided by m ans of a jumper tab 193 mounted on each electrical contact or jaw terminal in the socket adapter 40. A clip 192 is releasably engageable with the jumper tab 193 and carries one of the voltage lead line connections 182 or 184 thereon. The voltage lead connections 182 and 183 are input to a differential amplifier 185 which has a gain of 1/100 set by resistors 186 and 187. The output of the differential amplifier 185 is input to an A/D converter 124. The other line connections 183 and 184 are input to a similar combination of differential amplifiers thereby resulting in two separate voltage inputs as shown by reference numbers 190 and 191 in Figure 7 which are connected to inputs of the A/D converter 124. The differential amplifier 185 and the corresponding amplifier for the other lead line conductors provide an instantaneous voltage corresponding to the lead line voltage present on the conductors 182, 183 and 184 which is within the input range of the A/D converter 124. It should be understood that the input voltages supplied to the A/D converter 124 are instantaneous voltages.

The current sensing network of the AMR circuit 120 includes first and second current transformers 200 and 202, respectively, as shown in Figures 4, 5 and 15. The current transformers 200 and 202 include a high permeability toroid which is disposed around each of the customer line contacts 182 and 184, respectively, in the socket adapter 40.

The current transformers 200 and 202 are precision, temperature stable transformers which provide a ±10 volt output voltage signal in proportion to the instantaneous current flowing through the line conductors 134 and 136. In a physical mounting position, the current transformers 200 and 202 are disposed in the recess formed in the base 42 of the socket adapter 40 around the blade terminals of the socket adapter 40 extending through the recess between the shell 44 and the base 42 of the socket adapter 40. Each current transformer 200 and 202 may be

eccentrically or concentrically disposed about the respective blade terminal. Further, the electrical conductive coil of each current transformer 200 and 202 is covered by a protective insulating coating, with the conductive coil leads or outputs extending into the housing 121.

In a preferred embodiment, each of the toroids forming the current transformers 200 and 202 is fixedly connected to opposite sides of the housing 121, preferably adjacent one end thereof, as shown in Figures 4 and 15. The toroids 201 of each current transformer are preferably disposed substantially in line with the back wall of the housing 121 so as to be disposed between the bottom wall 90 of the shell 44 and the back wall of the base. The central aperture in each toroid 201 is sized to be disposed about the jaw terminals mounted in the socket adapter and extending through the base 70 and the shell 44.

The outputs from the current transformer 200 are input to a conditioning circuit which adjusts the burden voltage between -10 volts to +10 volts by means of a burden resistor 204 shown in Figure 7. The outputs of the current transformer 200 are each supplied to a separate amplifier 206 and 208, the outputs of which are respectively supplied as inputs to a differential amplifier 210. The output of the differential amplifier 210 which represents the scaled instantaneous current in the line conductor 134 is supplied as an input to the A/D converter 124 as shown in Figure 7.

A similar signal conditioning circuit is provided for the current transformer 202. The outputs from the current transformer 202 are supplied to separate differential amplifiers 211 and 212, the outputs of which are connected as inputs to a differential amplifier 213. The output of the differential amplifier 213 is also supplied as a separate input to the A/D converter 124.

The outputs of the voltage and current sense circuits are input to the A/D converter 124. In a preferred embodiment, the A/D converter 124 is a twelve-bit

+/-, self-calibrating, A/D converter, such as an A/D converter, Model No. LM12458C1V, sold by National Semiconductor Corporation. Clock input signals to the A/D converter are selected to provide a 64 per line cycle sample rate. In this manner, each of the voltage and current input signals supplied from the voltage sensing network 180 and the current sensing network 199 are sampled 64 times per cycle.

The clock input signals are generated by a clock signal 125 from a microcontroller 220, described hereafter, which is input to a J-K flip flop 127; Figure 8A. The Q output 129 of the flip flop 127 is connected to the clock input of the A/D converter 124 to provide the desired sample rate.

The A/D converter 124 includes internal sample and hold circuits to store continuous voltage and current signal representations before transmitting such instantaneous voltage and current representations to other portions of the AMR circuitry 120, as described hereafter.

A 2.5v voltage reference circuit, such as voltage reference circuit Model No. LT1029A CN8-2.5 sold by Linear Technologies, provides a voltage reference signal to the A/D converter 124 as shown in Figure 7.

The outputs from the A/D converter 124 are connected to a central processing unit 126. The central processing unit 126, in a preferred embodiment which will be described hereafter by way of example only, is a 16 bit microcontroller, Model No. HPC36004V20, sold by National Semiconductor Corporation. This microcontroller is a 16 bit microcontroller which executes a control program stored in the memory 128, as described hereafter, to control the operation of the AMR circuit 120.

The microcontroller 220 also drives a display means 222, such as a liquid crystal display, for displaying, for example, the total kilowatt hours and KVA of power usage and instantaneous voltage, current and power fact r values. Such a display 222 can be mounted, for

example, at a suitable location on the socket 30, for example, for easy visibility. The display 222, in a preferred embodiment, contains 16 characters including nine decimal digits divided into six significant digits and three decimal digits.

As shown in Figures 13 and 14, the display 222 can optionally be mounted in a separate cover 223 which includes a circular front wall and an annular side wall or flange 225. The display 222 is mounted in the cover 223 and has a suitable electrical connector 221 extending therefrom for connection to the AMR circuitry in the socket adapter when the cover 223 is mounted on the socket adapter 40. A resilient protective material layer 227 is mounted interiorly on the back side of the cover 223 to protect the display 222. The cover 223 is mounted on the socket adapter 40 in place of the watthour meter 34 and is fixedly attached thereto by means of a conventional sealing ring in the same manner as the sealing ring 68 used to attach the watthour meter 34 to the socket adapter 40. The display 222 will sequence between five different data values, including accumulated KWH and KVA and instantaneous voltage, current and power factor.

The memory 128, as shown in Figure 8C, includes a plurality of separate memory sections. The first memory section includes, by way of example only, two 32K × 8 bit EPROM memories 226 and 228. Two eight bit address busses 231A and 231B, Figures 8A and 8C, are output from the microcontroller 220 and pass through octal latches 238 to the address lines of the memories 226 and 228. Data buses 235A and 235B are also connected between the memories 226 and 228 and the microcontroller 220. The memory 128 also includes a non-volatile 8K × 8 bit clock RAM memory 230. The memory 230 acts as a timekeeping RAM clock. The memory 230 is provided with time information via an address bus from the microc ntroller 220 after a pow r outage. The memory 230 stores th date and time of any and all power outages and outputs such power outage information via an

output data bus which is connected between the memory 230 and the microcontroller 220. Finally, two 32K × 8 EEPROM memories 232 are provided as data storage for optional load survey information. The memories 232 are connected by the address buses 231A and 231B and the memory data buses 235A and 235B to the microcontroller 220 as shown in Figure 8C. The memories 232 are available to store load versus time information in the form of KVAR and KWH.

As shown in Figure 5, and in greater detail in Figure 9, the modem 130 receives inputs from the microcontroller 220 as well as from the A/D converter 124 and provides suitable data communication connections and data flow over the telephone conductors 22 connected thereto. By way of example only, the modem 130 is a two-way, 300 baud, reverse handshake modem, such as a single chip Bell 103 standard compatible modem data pump, which may be used on a call-in or called basis as described hereafter.

The modem 130 includes a single chip modem circuit 240, Model No. SS173K312, sold by Silicon Systems, which receives data signals from the microcontroller 220 and controls the serial transfer of data to and from the microcontroller 220. The transmit and receive pins of the modem circuit 240 are connected to corresponding pins on a direct access circuit 242, Model No. PN-73M9001, sold by Silicon Systems, Inc. which is connected to a relay 244 having two form contacts 245. The contacts 245 are connected to the coil of a relay 246. It should be noted that the RING and TIP input connections from the telephone network at the remote site are connected to both the circuit 242 and the relay 246.

As shown in Figure 5, the anti-tampering switch 250 is mounted within the housing 121 to detect any unauthorized movement of the housing 121 and the surr unding socket adapter 40 as would accompany an unauthorized attempt to remove the socket adapter 40 and/or watthour meter 34 from the socket h using 30 or to insert

wires through the socket adapter 40 into the socket housing 30. The switch 250 may be any suitable electrical switch which senses motion. For example, a reed-type mercury switch may be employed to detect any movement of the AMR after it has been installed in its use location by an authorized person.

The form C relay 252 is mounted in a separate housing 253 which is attachable to the housing 121 as shown in Figure 3. An opto signal transmitter 255 mounted in a window in the housing 121 is activated by the microcontroller 220 and transmits a light signal to an opto receiver 255 mounted in a window in the C relay housing 253. The opto receiver 255 activates the C relay 252 to switch the state of the contact 257 of the C relay 252. The double throw, single pole contact 257 may be employed for any suitable function, such as demand management load control devices, i.e., a disconnect switch or other external device to shed loads, terminate electrical service, etc. In the preferred embodiment, the relay 252 may be selectively activated so as to energize the contacts once during each 24 hour period.

The opto-coupler 254 is also mounted in the socket adapter and connected to the microcontroller 220. The opto-coupler 254 is responsive to light signals, such as infrared light signals, and functions to covert such light signals to electronic data signals. The coupler 254 includes a receiving unit 256 which is mounted in an aperture 255 in the shell 44 of the socket adapter 40 and extends outward from the shell 44. A cover, not shown, may be provided to sealingly enclose the receiving unit 256 of the opto-coupler 254 when the opto-coupler 254 is not in use. The opto-coupler 254 may be employed to receive light signals from transmitters on adjacent water and gas meters, for example, and to convert such light signals to electrical data signals which can be relayed by the microcontroller 220 via the telephone modem 22 to the central utility site 10 for subsequent data processing. In

addition, th opto-coupler 254 may be employed to set AMR parameters, such as voltage levels, clock signals, time windows, etc., directly at the remote customer site.

Remote AMR Control Program

Figures 10 and 11 depict the control program stored in non-volatile memory 226 and 228 which controls the operation of each remote AMR 18. After a power up, step 260 in Figure 10, the control program recovers the set up conditions for each particular AMR 18. Such set up condition recovery, step 262, occurs after the initial power up and after the power up occurring after each power loss. The reset conditions are used to reset the microcontroller 220 and provide data concerning the primary and alternate window dates and times of the particular AMR.

Next, in step 264, the current date/time stored in the RAM clock memory 230 is compared with the primary window date (day) and time (hour and minute) stored in the set up conditions for the particular AMR 18. If the current date/time does not equal the primary or alternate date/time window, step 266 is executed which disables the telephone ring detect circuit. Next, the power connections are checked in step 268. If the power connections are good, the data is displayed in step 270 before the control program returns to the data/time equal primary window step 264.

In step 268, the power check step tests the L1 and L2 conductors for the presence of voltage on both conductors, the proper voltage, and voltage within or outside of the specified voltage range. In the event that the power connections are determined to be bad in step 268, the super cap charger is disconnected in step 272. This disconnects the charging circuit to the real time clock RAM 230. The type of failure is recorded in step 274 and the type of failure, i.e., whether complete or other, is checked in step 276. If the failure is a complete failure, the control program ceases execution until the next power up occurs. If a non-complete failure ccurs, the super cap

charging circuit is reconnected in step 278, the data displayed in step 270 and program control returns to step 264.

The control program stored in the memory 226 and 228 is devised to store data relating to a plurality of separate power outages. For example only, data pertaining to ten different power outages may be stored in the memory 226 and 228 via step 224 in the control program described above. Such data includes the number of power outage currents as well as the month, day, hour, minute of the occurrence of the power outage and the duration in minutes and hours of each power outage. This data is transferred from the AMR to the central computer during normal data reporting, as described hereafter.

If the date/time check in step 264 determines that the current date/time equals the primary or alternate programmed window, the AMR is moved into an answer mode in step 280. If the AMR is programmed to receive data, thereby indicating a proper answer mode condition, the control program causes the AMR to enable the telephone ring detect circuit in step 282 before looping to step 268. If an answer mode is not entered in step 280, the pick-up detection circuit is enabled in step 284 and telephone modem communication is then initiated in step 286. The pick-up detection circuit will detect the occurrence of a customer picking up the telephone during a data transfer. When this occurs, a subroutine labelled pick-up detect interrupt request (IRQ), step 288 in Figure 11, is executed. In this subroutine, which occurs only when the pick-up detection circuit has been enabled and a customer picks up the telephone during a data transfer to the central utility site 10, the AMR will release its connection to the customer telephone line in step 290 and enable the alternate window for later data transfer. The day, hour and minute of the alternate or s condary window is stored in the memory 226 and 228. This information is initially programmed into the mem ry 226 and 228 by the

central computer 12 during initialization of the remote AMR. Control then returns to the primary program loop described above.

After the modem communication has been initiated in step 286, data will be transferred from the remote AMR 18 to the central utility site 10 in step 292, Figure 10. Finally, the pick-up detection circuit is disabled in step 294 to complete this program loop.

Various interrupt subroutines are shown in Figure 11. The timed interrupt request (timed IRQ) 300 is a non-masked interrupt and occurs at all times and with a primary status over all other interrupt requests. Timed IRQ, step 300, occurs every 260.4 microseconds based on 64 samples per cycle. When this interrupt request occurs, data acquisition starts in step 302 in which the A/D converter values are read into the microcontroller 220, the calculations, described hereafter, are performed on such data in step 304 and the results stored in memory 226 and 228 in step 306. At the completion of the memory storage step 306, control returns to the primary program loop described above and shown in Figure 10.

At the periodic sample rate of 64 samples per cycle, or once every 260.4 microseconds, the digital values corresponding to the instantaneous voltage and current will be input to the micorcontroller 220, as described above. The microcontroller 220 then executes a calculation subroutine to determine the kilowatt hours of electrical power consumed since the last sample. According to the equation:

$$KWH = K \cdot Vrms \cdot Irms \cdot (T2 - T1), \text{ where}$$

K is a calibration constant
T1 is the preceding sample time
T2 is the current sample time

The control program also calculates the power factor, KVAR, according to known electrical power factor and VAR equations.

Furthermore, the instantaneous current and voltage data at the sample rate is input to the microcontroller 220 for each separate line L1 and L2 or phase of electrical power. Separate power, instantaneous voltage and current and power factor data is stored in the memory 226 and 228 by the microcontroller 220 for each phase or line at each sample period.

When a ring detect interrupt request (IRQ) occurs in step 308, the control program will enable the pick-up detect circuit in step 310 and initiate modem communication in step 312 via a conventional handshake protocol. Data stored in the memories 226 and 228 is then transferred in step 314 via the telephone modem 130 and telephone line conductors to the central utility site 10. In step 316, the pick-up detection circuit is disabled and the telephone line is then released in step 318.

Finally, a subroutine labelled RS-232 detect IRQ, step 320, detects a request for serial data communication. When this interrupt occurs, serial communication is initiated in step 322 and the data is transferred in step 324 via opto-coupler 254. The end of communication is detected in step 326 before control returns to the primary control loop.

It should also be noted that the RS-232 detect interrupt request and the ring detect interrupt request signals, steps 308 and 320, are mutually exclusive such that when the ring detect is enabled, the RS-232 interrupt request is disabled and vice versa. Similarly, when the timed IRQ subroutine, step 300, interrupt request is received, the RS-232 interrupt detect is disabled. At the completion of the timed IRQ subroutine, the RS-232 detect interrupt request is re-enabled and, if previously interrupted, will complete its serial data communication.

In summary, there has been disclosed a unique remote automatic meter reading apparatus which senses, calculates and stores electrical power consumption values at each of a plurality of electrical utility customer sites

and communicat s such power consumption values at predetermined times to a centrally located utility site. The apparatus of the present invention also includes a unique socket adapter mountable in a watthour meter socket which contains the remote AMR circuitry for each remote site in a compact package thereby eliminating the need for extra enclosures at each remote customer site.

What is Claimed is:

1. An electric power consumption measurement apparatus for measuring the electrical power consumed at each of a plurality of customer sites remotely located from a central utility site and connected to electrical utility power conductors, the apparatus comprising:

central processor means, disposed at the central utility site and executing a stored program, for interrogating each customer site and accumulating electrical power consumption values from each customer site;

automatic electrical power consumption measuring means, mounted at each customer site, and coupled to the electrical utility power conductors at each customer site, for automatically measuring and calculating the electrical power consumed at each customer site, the automatic power consumption measuring apparatus at each customer site including:

current sense means for sensing the instantaneous values of current drawn by a load at a customer site at a predetermined sample interval;

voltage sense means for sensing the instantaneous voltage supplied to a customer site at the predetermined sample interval;

means, responsive to the current sense means and the voltage sense means, for generating digital values of the instantaneous current and voltage quantities at each sample interval;

processor means, executing a stored program and responsive to the digital values of the instantaneous current and voltage, for computing the instantaneous power consumed at a customer site;

memory means, responsive to the processor means, for storing the control program executed by the processor means and for storing accumulated instantaneous electrical power values; and

communication interface means, having a first portion at the central utility site and a second portion at each customer site and responsive to the central processor means and the processor means at each customer site, for establishing communication between the central processor means and each processor means at each customer site for the transmission of accumulated power consumption values from each customer site to the central utility site.

2. The apparatus of Claim 1 wherein the current sense means comprises:

a plurality of current sensing coils disposed about the utility power conductors at each customer site, an output of each of the current sensing coils being input to the means for generating digital current values.

3. The apparatus of Claim 1 wherein the voltage sense means comprises:

amplifier means, connected to the electrical utility power conductors at each customer site, for generating a signal proportional to the instantaneous voltage on the electrical power conductors, the output of the amplifier means being input to the means for generating digital voltage values.

4. The apparatus of Claim 1 further comprising:

the processor means executing a stored program to integrate the digital instantaneous current and voltage values input thereto to calculate real and reactive kilowatt hours consumed at the customer site, the real and reactive kilowatt hour values being stored in the memory means.

5. The apparatus of Claim 1 wherein the communication interface means comprises:

telephone conductors extending between the c ntral utility site and each remote customer site;

first modem means, at the central utility site and responsive to the central processor means, for connecting the central processor means to the telephone conductors; and

second modem means, at each customer site and responsive to the processor means at each customer site, for connecting the processor means at each customer site in data communication with the central processor means over the telephone conductors.

6. The apparatus of Claim 1 wherein:

the predetermined sample interval is one sample per 260.4 microseconds.

7. The apparatus of Claim 6 wherein at least two separate electrical power line conductors and one neutral conductor are connected to each customer site, the apparatus further comprising:

separate current sense means for sensing the instantaneous values of current drawn by a load at a customer site at a predetermined sample interval for each of the power line conductors connected to each customer site;

separate voltage sense means for sensing the instantaneous voltage applied to each power line conductor at a customer site at the predetermined sample interval;

the means for generating digital values of the instantaneous current and voltage quantities at each sample interval being responsive to the separate current sense means and separate voltage sense means for generating separate digital values of the instantaneous current and voltage quantities on each separate power line conductor;

the processor means computing the instantaneous power consumed at a customer site for each separate power line conductor; and

the memory means storing accumulated instantaneous electrical power values for each separate power line conductor at a customer site.

8. The apparatus of Claim 1 wherein:

first time window data is stored in the memory means for establishing a first day and time of data communication between the processor means at a customer site and the central processing means.

9. The apparatus of Claim 8 wherein:

the memory means further includes second time and date data for establishing a second time and date for data communication between the processor means at a customer site and the central processing means.

10. The apparatus of Claim 1 wherein the communication interface means further comprises:

means, responsive to a customer pickup of a telephone at a customer site during communication between the central processor means and the processor means at the customer site, for discontinuing communication between the central processor means and the processor means at the customer site.

11. The apparatus of Claim 1 wherein the processor means at each customer site further comprises:

means for detecting a power outage at a customer site; and

means for storing in the memory means the number of the power outage during a predetermined period, the time of the power outage and the duration of the power outage.

12. A remote electric watthour meter reader apparatus including a central c mputer connected by telephone communication means with each of a plurality of individually addressable, remotely located, user sites,

each user site having at least one electric watthour m ter removably interconnected between line and load conductors in a meter socket to measure electric power consumed at each user site, the apparatus comprising:

a watthour meter socket adapter including:

a housing;

a watthour meter receiving portion formed in the housing;

a plurality of electrical contacts mounted in the watthour meter receiving portion for removably receiving blade terminals of a watthour meter in a snap-in connection;

a plurality of electrical terminals mounted on and extending outward from the housing of the socket adapter and engagable with a plurality of electrical contacts mounted in the meter socket and connected to the line and load electrical power conductors; and

electrical power consumption reading and accumulation means, mounted in the socket adapter housing, for reading and accumulating the electrical power consumed at a user site and for transmitting accumulated power representations to the central computer.

13. The apparatus of Claim 12 wherein the socket adapter housing comprises:

a base having an internal cavity, a plurality of slots formed in the base for receiving the blade terminals therethrough;

a shell having an internal cavity, the shell fixedly connected to the base over the internal cavity in the base and having slots formed thereon for receiving blade terminals extending through the base; and

the power consumption r ading and accumulation means being m unted in the base and the shell of the socket adapter housing.

14. The apparatus of Claim 13 wherein the power consumption reading and accumulation means further comprises:

a receptacle, the power consumption reading and accumulation means being mounted in the receptacle;

an aperture formed in the bottom wall of the shell and communicating with the internal cavity in the base;

the receptacle mounted on the base and extending through the aperture in the bottom wall of the shell into the interior cavity of the shell.

15. The apparatus of Claim 14 further comprising:

means for shielding the interior of the receptacle from electromagnetic radiation.

16. The apparatus of Claim 15 wherein the shielding means comprises:

the receptacle being formed of plastic and having a metal coating disposed thereon.

17. The apparatus of Claim 12 further comprising:

anti-tampering detection means, mounted in the housing, for detecting movement of the housing after the initial installation of the power consumption reading and accumulation means in the housing, the anti-tampering detection means providing an output upon the occurrence of any movement thereof.

18. The apparatus of Claim 13 further comprising:

opto-coupler means, mounted in the shell, for receiving optical data signals from an external source and for converting the optical data signals to digital electrical signals input to the process r means.

19. The apparatus of Claim 12 further comprising:

relay means, mounted in the housing and responsive to the processor means, for generating an output upon selective energization by the processor means.

20. The apparatus of Claim 14 further comprising:

a plurality of current sensing coils fixedly mounted to the receptacle, each current sensing coil being disposed about a blade terminal extending through the shell and the base of the socket adapter housing when the receptacle is mounted in the housing.

21. The apparatus of Claim 13 further comprising:

a plurality of current sensing coils mounted in the internal cavity in the base of the socket adapter housing, each current sensing coil disposed about a blade terminal extending between the shell and the base of the socket adapter housing.

22. The apparatus of Claim 12 further comprising:

telephone communication connection means, mounted in the socket adapter housing for data communication via the telephone communication means with the central computer.

23. The apparatus of Claim 12 further comprising:

current sensing means for sensing the instantaneous value of current drawn by a load at a customer site over a sample interval;

voltage sensing means for sensing the instantaneous voltage supplied to each customer site over the sample interval;

analog to digital signal conversion means, responsive to the current and voltage sensing means, for generating digital values of the sensed current and voltage during the sample interval;

central processing means, executing a stored program and responsive to the digital current and voltage values, for computing the instantaneous power consumed at the customer site;

memory means, responsive to the central processing means, for storing a control program executed by the central processing means and for accumulating power values consumed at a user site; and

communication means, responsive to the central processing means and the remote central computer, for establishing data communications between the central processing means and the central computer.

24. The apparatus of Claim 22 wherein the communication means comprises:

a telephone jack mounted in the watthour meter socket adapter housing for connection to telephone line conductors, an output of the telephone jack being electrically connected to the communication means.

25. The apparatus of Claim 24 further comprising:

a hollow sleeve mounted externally to the watthour meter socket adapter housing and communicating with the watthour meter receiving portion, the telephone jack being mounted in the sleeve, the telephone line conductors extending through the sleeve to the telephone jack.

26. The apparatus of claim 23 further comprising:

a hollow sleeve having first and second opposed ends;

an aperture formed in a side wall of th shell;

first fastening means for fastening the sleeve to the side wall of the shell;

telephone line connector means, mounted in the sleeve, for connecting the communication means to external telephone line conductors; and

cover means for sealingly closing the second end of the sleeve to control access to the telephone connector means in the sleeve separate from access to the watthour meter receiving portion of the housing.

27. The apparatus of claim 26 wherein the telephone connector means comprises:

a telephone phone jack mounted in the sleeve for receiving a mating telephone jack connected to one end of the external telephone line conductors in a plug-in connection.

28. The apparatus of claim 26 wherein the telephone connector means comprises:

first and second telephone jacks mounted in the sleeve;

the first telephone jack receiving a mating telephone jack connected to one end of the external telephone line conductors in a plug-in connection;

the second telephone jack receiving a mating telephone jack connected to a conductor extending from the telephone communication means.

29. The apparatus of claim 26 further comprising:

second fastening means for removably mounting the cover means to the sleeve; and

seal means closingly insertable through the second fastener means to indicate a sealed condition of the cover means.

30. The apparatus of claim 29 wherein the second fastening means comprises:

threaded studs extending through the side wall of the shell, the sleeve and the cover; and

wing nuts threadingly engaging the exterior ends of the threaded studs.

31. The apparatus of claim 30 wherein the seal means comprises:

apertures formed in each of the wing nuts for receiving a wire seal therethrough in a closable loop through all of the wing nuts.

32. The apparatus of claim 26 further comprising:

strain relief means mounted in the cover means, for receiving the external telephone line conductors therethrough.

33. A remote electric watthour meter reader apparatus including a central computer connected by telephone communication means with each of a plurality of individually addressable, remotely located, user sites, each user site having at least one electric watthour meter socket having jaw contacts connected between line and load conductors, to measure electric power consumed at each user site, the apparatus comprising:

a watthour meter socket adapter including:

a housing;

a watthour meter receiving portion formed in the housing;

a plurality of electrical contacts mounted in the watthour meter receiving portion for removably receiving blade terminals of a watthour meter in a snap-in connection, a terminal end portion formed on each of the electrical contacts and extending outward from the h using of the socket adapter and engagable

with the jaw contacts in the watthour meter socket; and

electrical power consumption reading and accumulation means, mounted in the socket adapter housing, for reading and accumulating the electrical power consumed at a user site and for transmitting accumulated power representations to the central computer.

34. The apparatus of Claim 33 further comprising:

a cover sealingly mountable on the housing of the watthour meter socket adapter, the cover closing the watthour meter receiving portion of the housing.

35. The apparatus of Claim 34 further comprising:

display means, mounted in the cover and responsive to the processor means, for displaying electrical power values at a customer site.

36. A method for metering an electrical power supply having first and second parameters exhibiting a periodic cycle phase relationship comprising the steps of:

scaling the power supply to provide first and second scaled electrical parameter signals proportional to the first and second parameters of the power supply;

sampling the first and second scaled electrical parameter signals once during each of a plurality of predetermined periodic sample intervals during each cycle of the first and second parameters to generate instantaneous first and second scaled electrical parameter signals, the first and second electrical parameters being sampled consecutively at each sample time;

conv rting the first and second scaled el ctrical parameter signals at each sample time to binary first and second electrical parameter signals;

at the end of each sample interval, calculating electrical metering values based on the binary first and second electrical parameter signals during the sample interval without correction for phase differences between the sample time of each of the first and second electrical parameters; and

storing the calculated electrical metering values in a memory.

37. The method of claim 36 further comprising the steps of:

integrating the calculated electrical metering values over a predetermined time interval based on the accumulated electrical metering values to obtain total electrical metering values over the predetermined time interval.

38. The method of claim 37 further comprising the steps of:

transmitting the total electrical metering values at a predetermined time and date to a remote processing means.

39. The method of claim 36 wherein the first and second electrical parameters are sampled 64 times per cycle.

40. The method of claim 1 wherein the first and second electrical parameters are voltage and current, respectively.

41. The method of claim 40 wherein the calculated electrical metering value is power.

42. A method for calculating electrical power consumed at a electric utility customer site comprising the steps of:

scaling the cyclic voltage and current at the customer site to derive scaled voltage and current scaled analog signals;

sampling the scaled voltage and current signals once for each of a plurality of sample intervals during a predetermined time interval to obtain instantaneous voltage and current values at each sample time;

converting the instantaneous voltage and current values to digital binary representations of the instantaneous voltage and current values;

storing the digital instantaneous voltage and current values in a memory for each sample time during the predetermined time interval;

at the end of each sample interval, calculating the power consumed at the customer site based on the digital binary representations of the voltage and current values during the sample interval; and

storing the calculated power consumed for each sample interval in a memory.

43. The method of claim 42 wherein the predetermined time interval is each 360° cycle of electrical voltage at the customer site.

44. The method of claim 42 further comprises the step of:

calculating the power from the accumulated digital instantaneous voltage and current values without adjusting the voltage and current values for phase differences between the sample times of the voltage and current signals.

45. The method of claim 42 wherein:

the instantaneous voltage and current values at each sample interval are analog values; and

the step of converting comprises the step of converting the analog voltage and current signals to a 12 bit digital binary signal.

46. The method of claim 45 wherein the voltage current signals are sampled 64 times per cycle.

47. The method of claim 37 further comprising the step of integrating the digital binary voltage and current values of each sample interval over the predetermined time interval.

48. The method of claim 42 further comprising the steps of:

connecting at least two separate electrical power line conductors and one neutral conductor to the customer site;

scaling the voltage and current on each power line conductor at the customer site to derive voltage and current scaled analog signals;

sampling each of the scaled voltage and current signals on each power line conductor once for each of a plurality of sample intervals during a predetermined time interval to obtain instantaneous voltage and current values at each sample time;

converting the instantaneous voltage and current values to digital instantaneous voltage and current values;

storing the digital instantaneous voltage and current values for each power line conductor in a memory during each sample interval;

at the end of each sample interval, calculating the power consumed at the customer site during the sample interval based on the digital voltage and current values of each power line conductor; and

storing the calculated power consumed for each sample interval in a memory.

49. The m thod of claim 42 further comprising: establishing a first time window including a first day and a first time for data communication between a processor and the memory at the customer site and a central processing means at a central utility site; and connecting the processor at the customer site to the central processing means to communicate calculated total power values to the central processing means.

50. The method of claim 49 further comprising the steps of: establishing a second day and second time window for alternate data communication between the processor at the customer site and the central processing means.

51. The method of claim 49 further comprising the steps of: interrupting and discontinuing the communication between the customer site and the central processing means upon pickup of a telephone at the customer site during communication between the central processor means and the processor.

52. The method of claim 42 further comprising the steps of: detecting a power outage at the customer site; storing the time of day and duration of each separate power outage at the customer site during a predetermined time period in a memory; and transmitting the time of day and duration of each power outage at the customer site to a remote processor.

53. A remote metering apparatus including a central computer connected by telephone communication means with each of a plurality of individually addressable, remotely located, user sit s, each user site having at least one electric watthour meter socket having jaw

contacts connected between electrical line and load conductors, the apparatus comprising:

a housing;

a plurality of electrical contacts mounted in the housing, a terminal end portion of each of the electrical contacts extending outward from the housing and engagable with the jaw contacts in the watthour meter socket;

sensing means mounted in the housing for sensing varying parameters at the user site;

converting means, mounted in the housing and responsive to the sensing means, for converting at least certain sensed parameters into digital binary representations of the sensed parameters;

processor means, mounted in the housing, and responsive to the converting means, for storing the digital binary representations of the sensed parameters in a memory and for calculating total parameter values for at least certain of the parameters over a predetermined time interval; and

communication means, responsive to the processor means and the central computer, for communicating the stored total parameters to the central computer.

54. The apparatus of claim 53 further comprising:

a cover sealingly mountable on the housing.

55. The apparatus of claim 53 further comprising:

visual display means, mounted on the housing and responsive to the processor means, for displaying at least certain parameter values at the customer site.

56. The apparatus of claim 53 wherein the housing comprises:

a base having an internal cavity, a plurality of slots formed in the base for receiving the terminal end portions of the contacts therethrough;

a shell having an internal cavity, the shell fixedly connected to the base over the internal cavity in the base, the terminal end portions of the contacts disposed in the internal cavity in the base;

a plurality of current sensing coils each disposed about a terminal end portion of one of the contacts extending through the internal cavity in the base; and

the processor and the converting means being mounted in the base and the shell of the housing.

57. The apparatus of claim 53 further comprising:

opto-coupler means, mounted in the housing, for receiving optical data signals from an external source and for converting the optical data signals to digital electrical signals input to the processor means.

58. The apparatus of claim 53 wherein the communication means comprises:

telephone communication connection means, mounted in the housing for data communication via the telephone line conductors with the central computer.

59. The apparatus of claim 58 wherein the telephone communication connection means comprises:

a first telephone jack mounted in the housing, an output of the telephone jack being electrically connected to the communication means;

a hollow sleeve mounted externally to the housing and communicating with the interior of the housing; and

a second telephone jack mounted in the sleeve and connected to the first telephone jack in the housing, the

telephone line conductors extending through the sleeve to the second telephone jack.

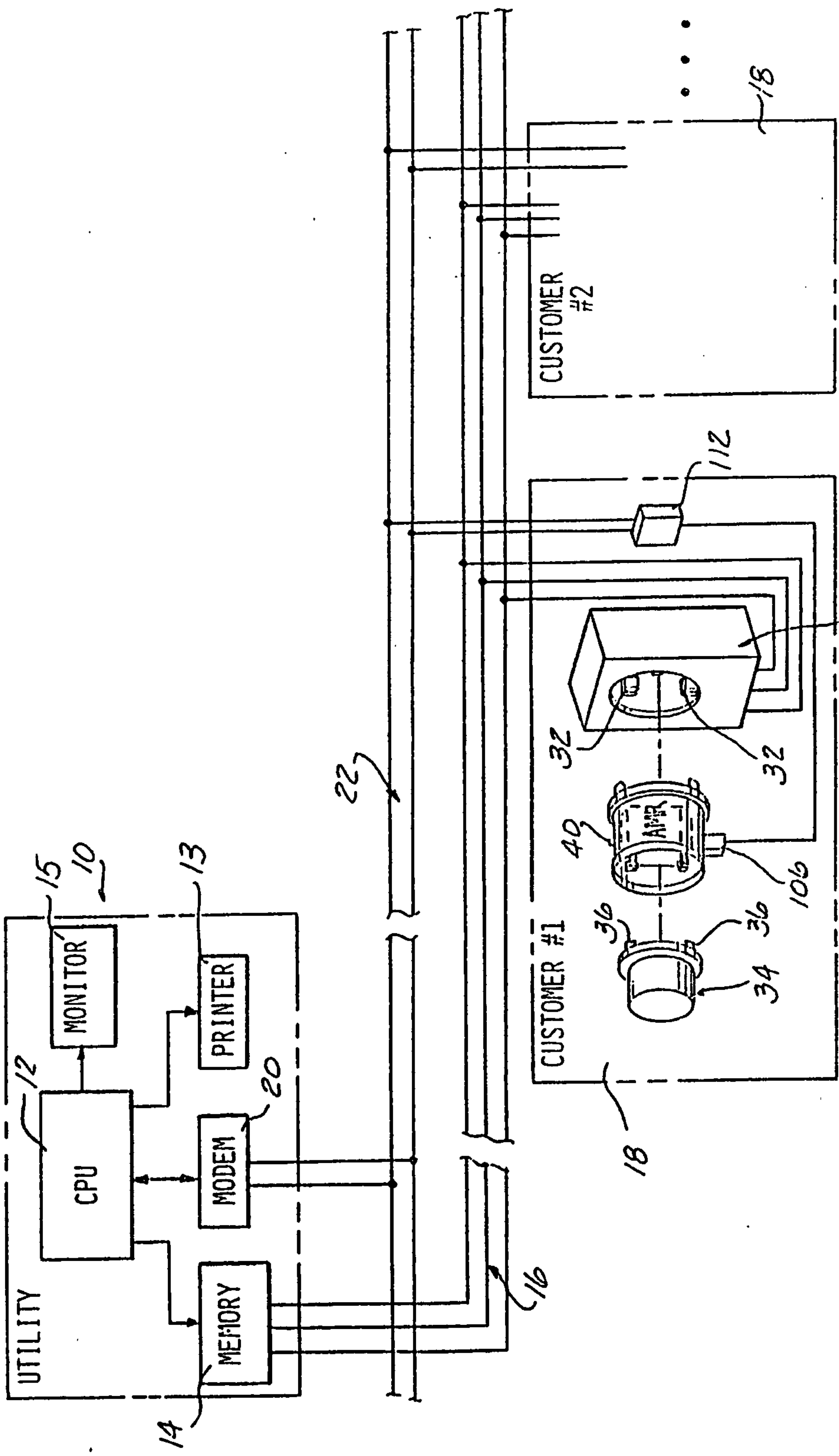
UTILITY
MONITOR
PRINTER
CPU
MODEM
MEMORY
CUSTOMER #1
CUSTOMER #2
APR

FIG - I

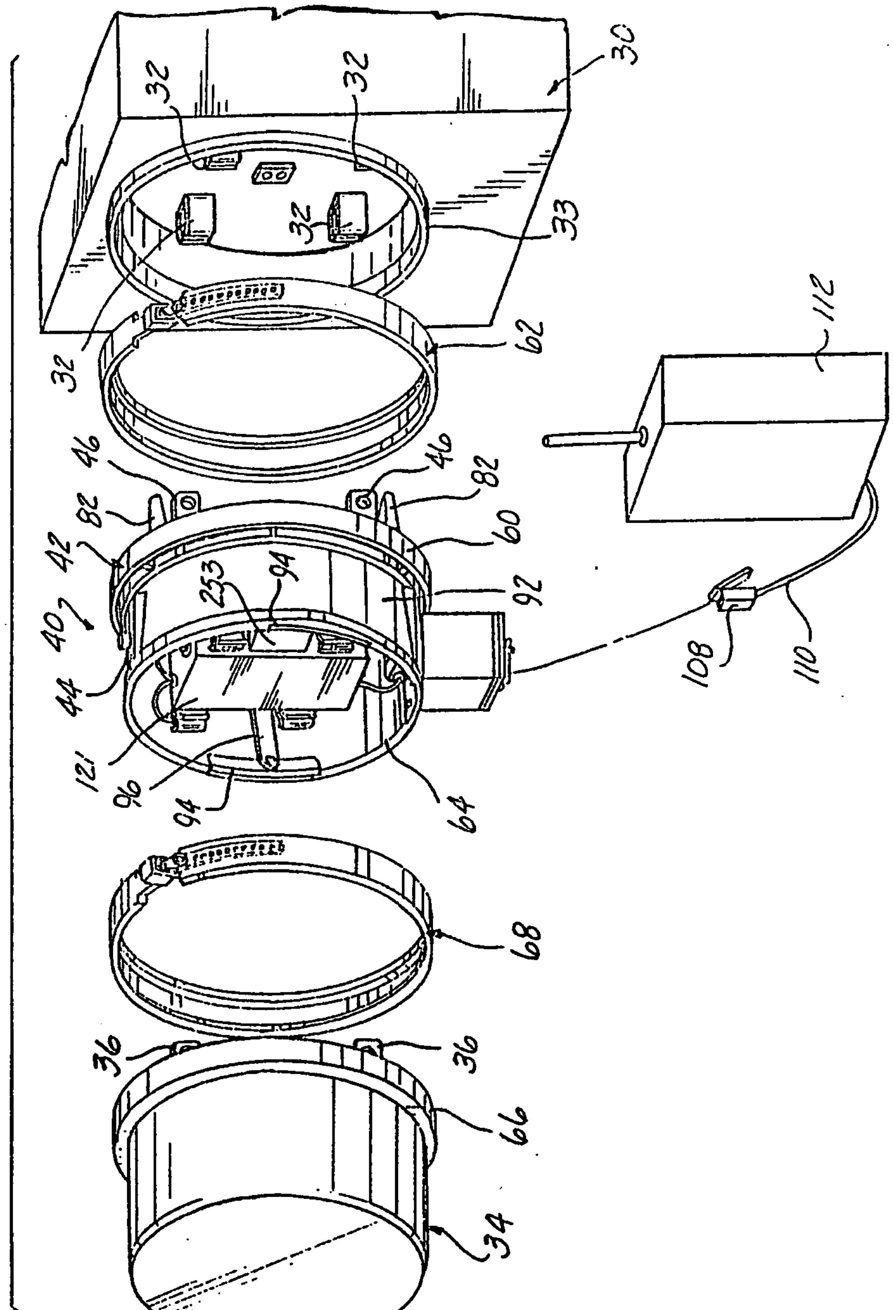
30
32
32
32
33
32
62
112
46
46
82
82
42
60
92
94
253
40
44
121
96
94
64
108
110
68
36
36
66
34

FIG-2

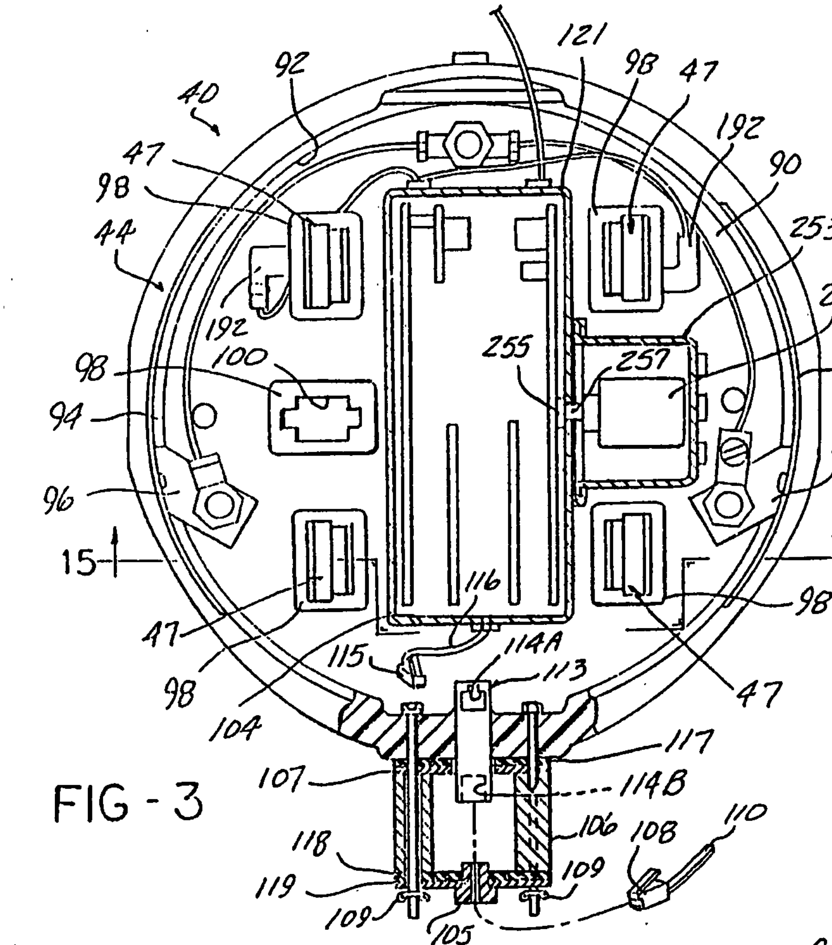
40
92
121
98
47
192
90
47
98
44
253
252
192
255
257
98
100
94
94
96
96
15
15
116
47
98
98
115
114A
113
104
117
107
114B
118
106
108
110
119
109
109
105

FIG - 3

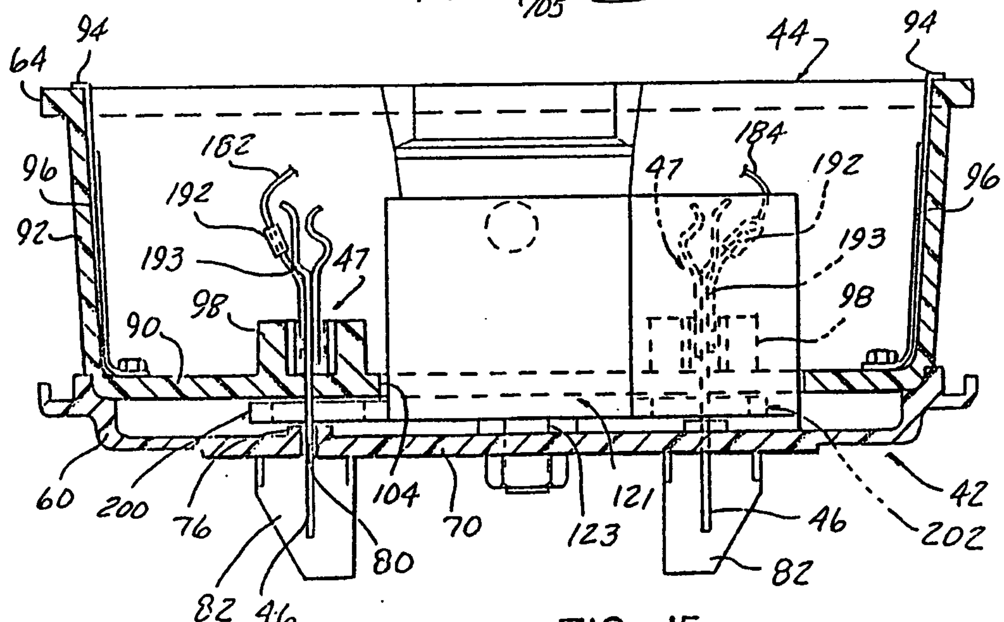
64
94
44
94
182
184
96
47
192
96
192
92
193
47
193
98
98
90
60
200
76
104
70
121
123
42
202
46
80
82
46
82
46

FIG -15

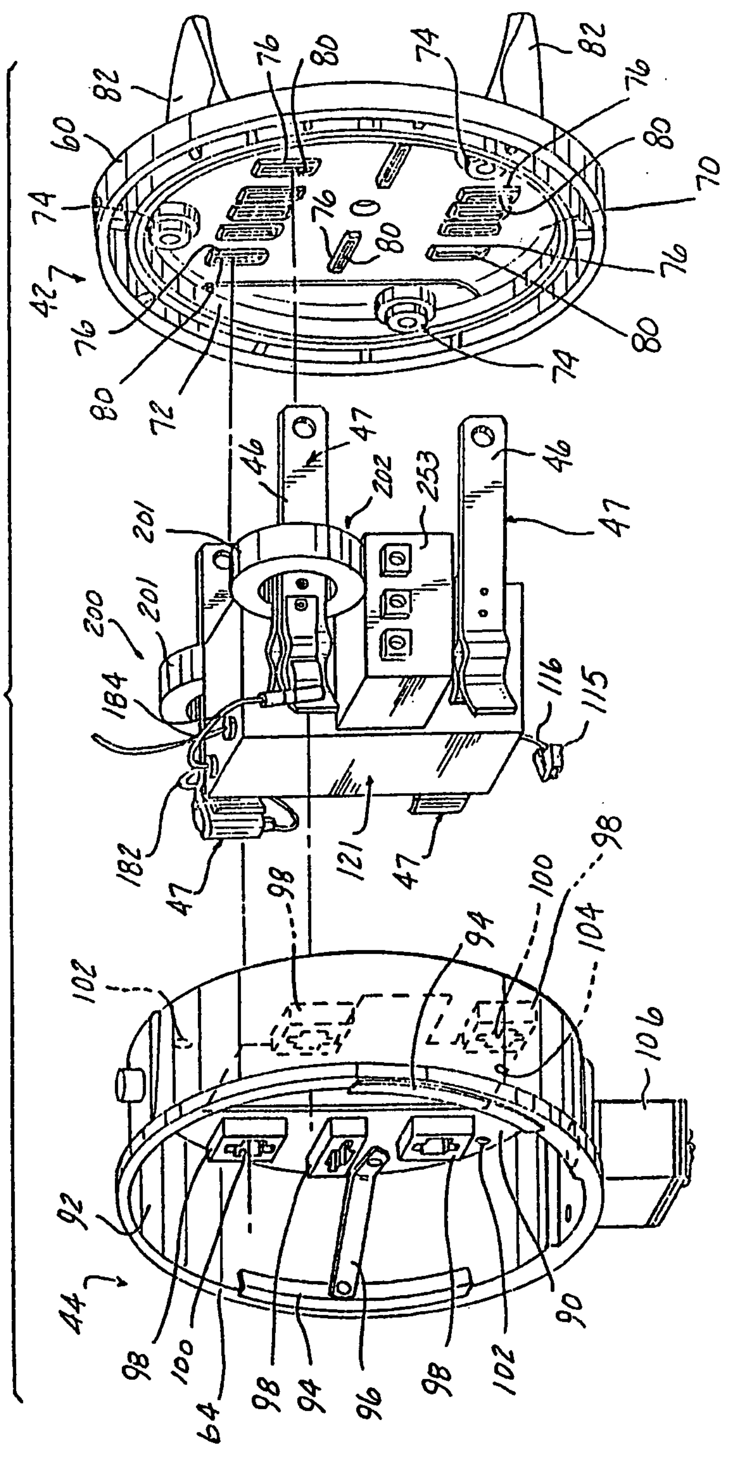
40
42
44
46
47
60
64
70
72
74
76
80
82
90
92
94
96
98
100
102
104
106
115
116
121
182
184
200
201
202
253

FIG-4

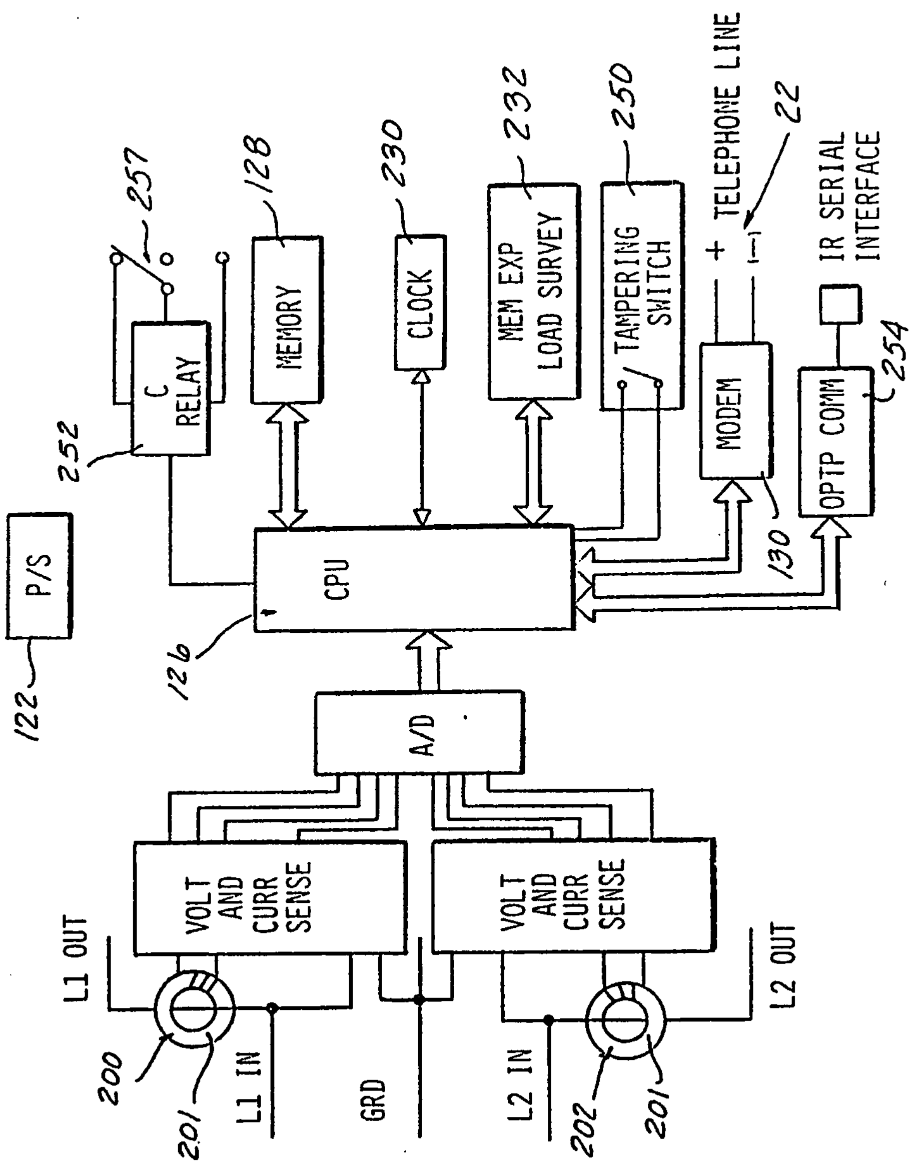
P/S
122
C
RELAY
252
257
MEMORY
128
CLOCK
230
MEM EXP
LOAD SURVEY
232
TAMPERING
SWITCH
250
+ TELEPHONE LINE
(—)
22
MODEM
130
IR SERIAL
INTERFACE
OPTP COMM
254
CPU
126
A/D
VOLT
AND
CURR
SENSE
VOLT
AND
CURR
SENSE
L1 OUT
L1 IN
200
201
GRD
L2 IN
L2 OUT
202
201

FIG-5

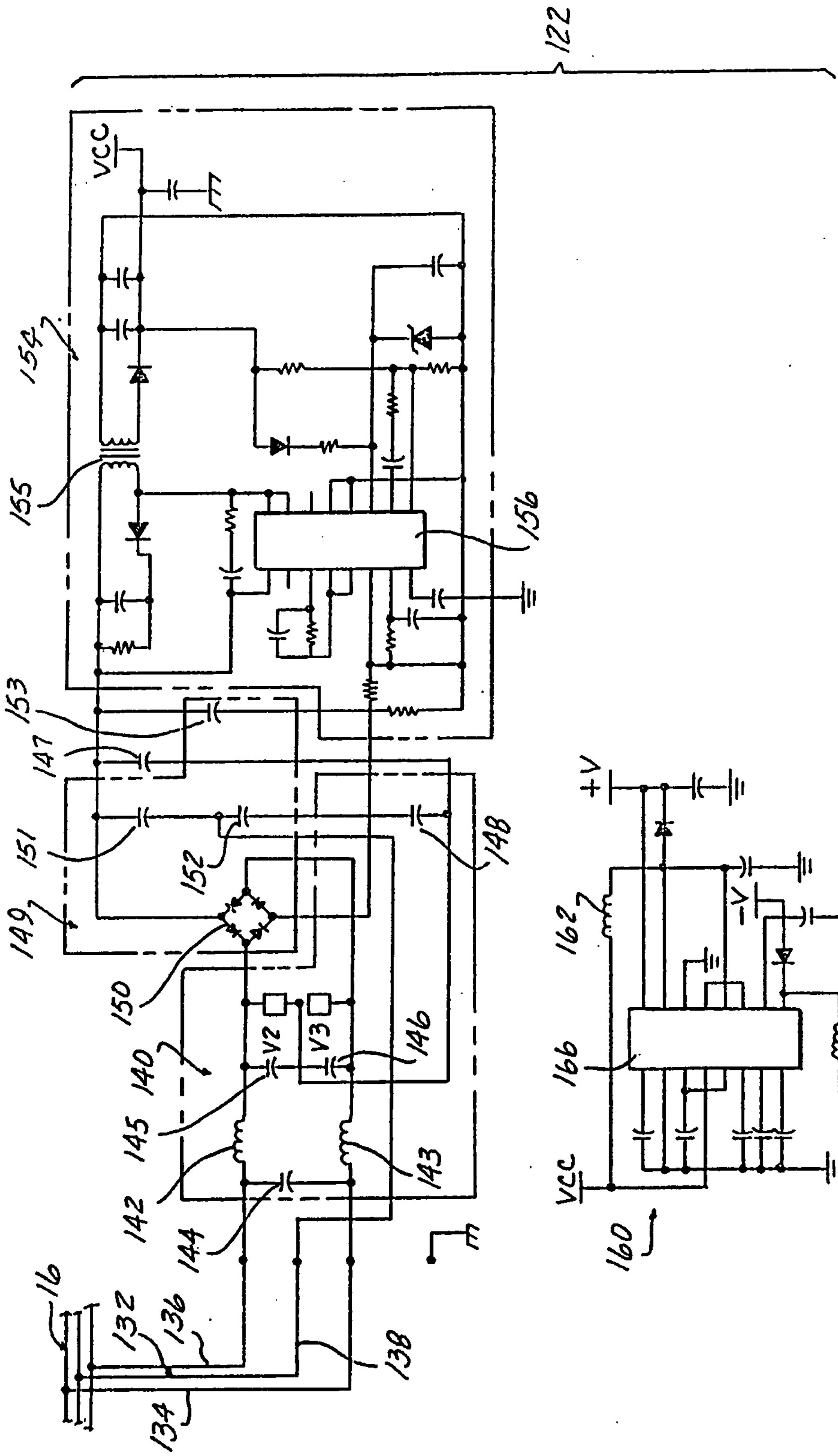
122
VCC
154
155
156
153
147
151
152
148
149
150
140
145
146
V2
V3
142
143
144
16
132
136
134
138
+V
-V
162
164
166
VCC
160

FIG - 6

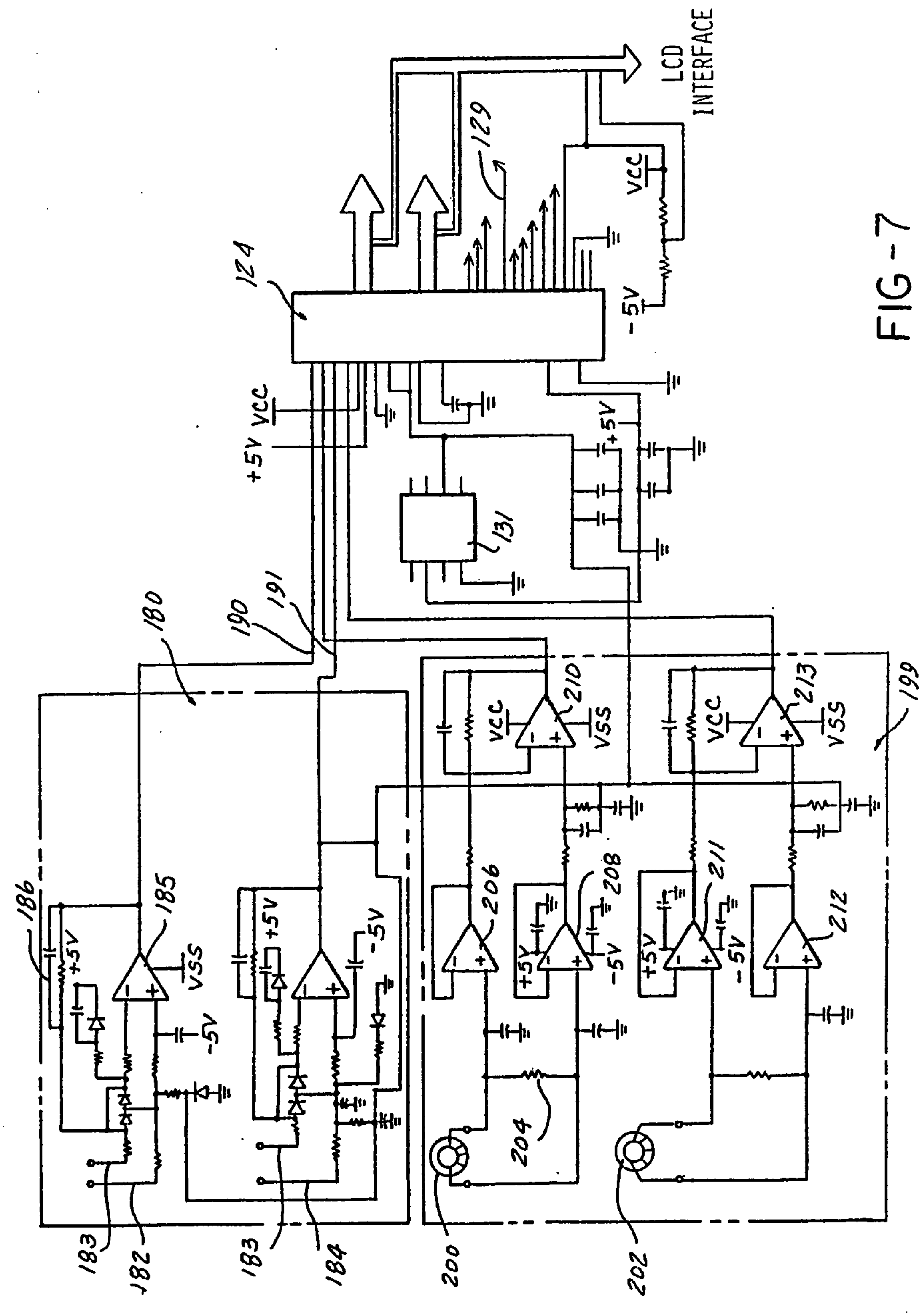
LCD INTERFACE
124
129
VCC
-5V
+5V
+5V
VCC
131
180
190
191
210
213
VCC
VSS
199
186
185
+5V
VSS
-5V
-5V
206
208
211
212
204
183
182
183
184
200
202

FIG-7

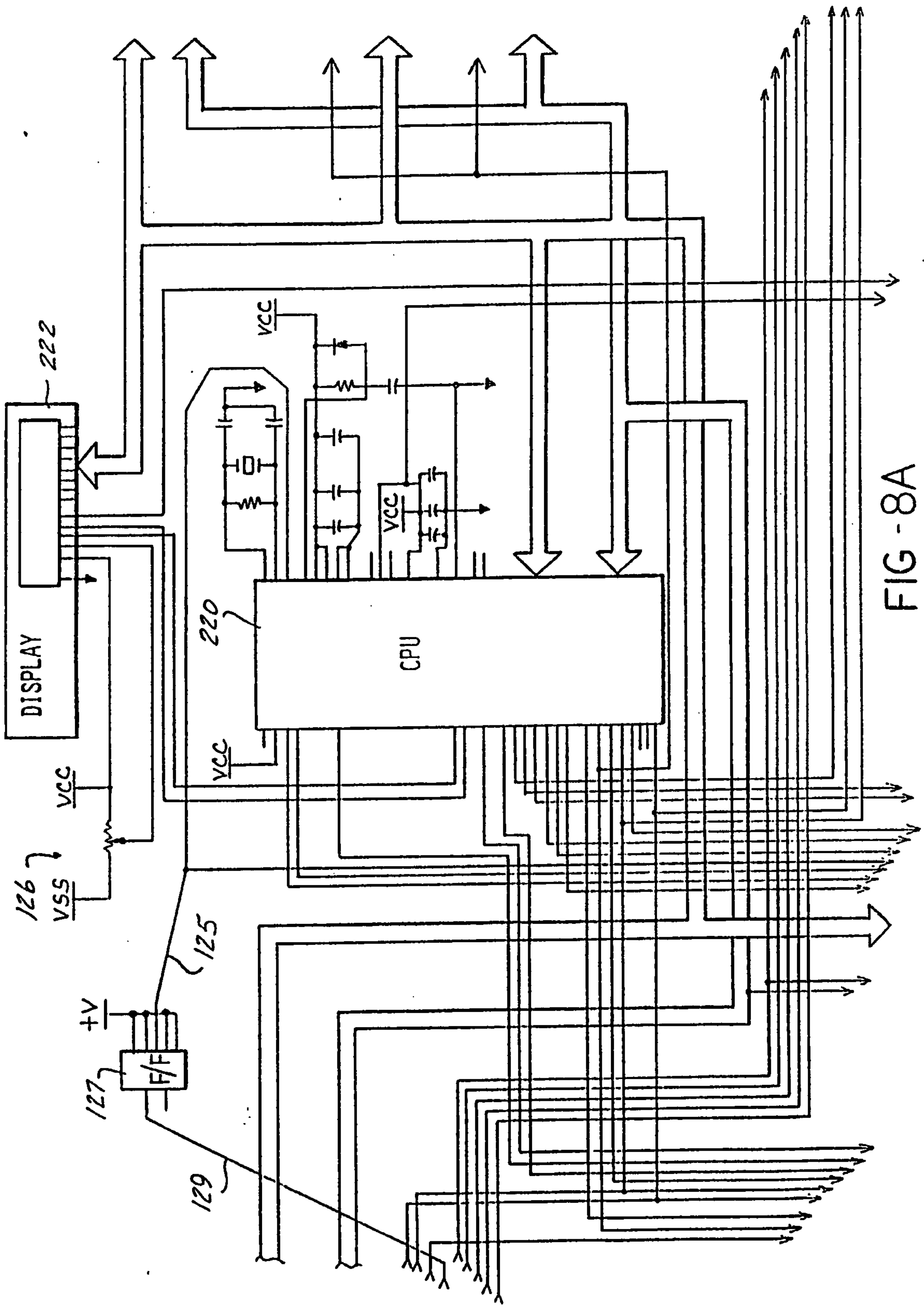

FIG-8A

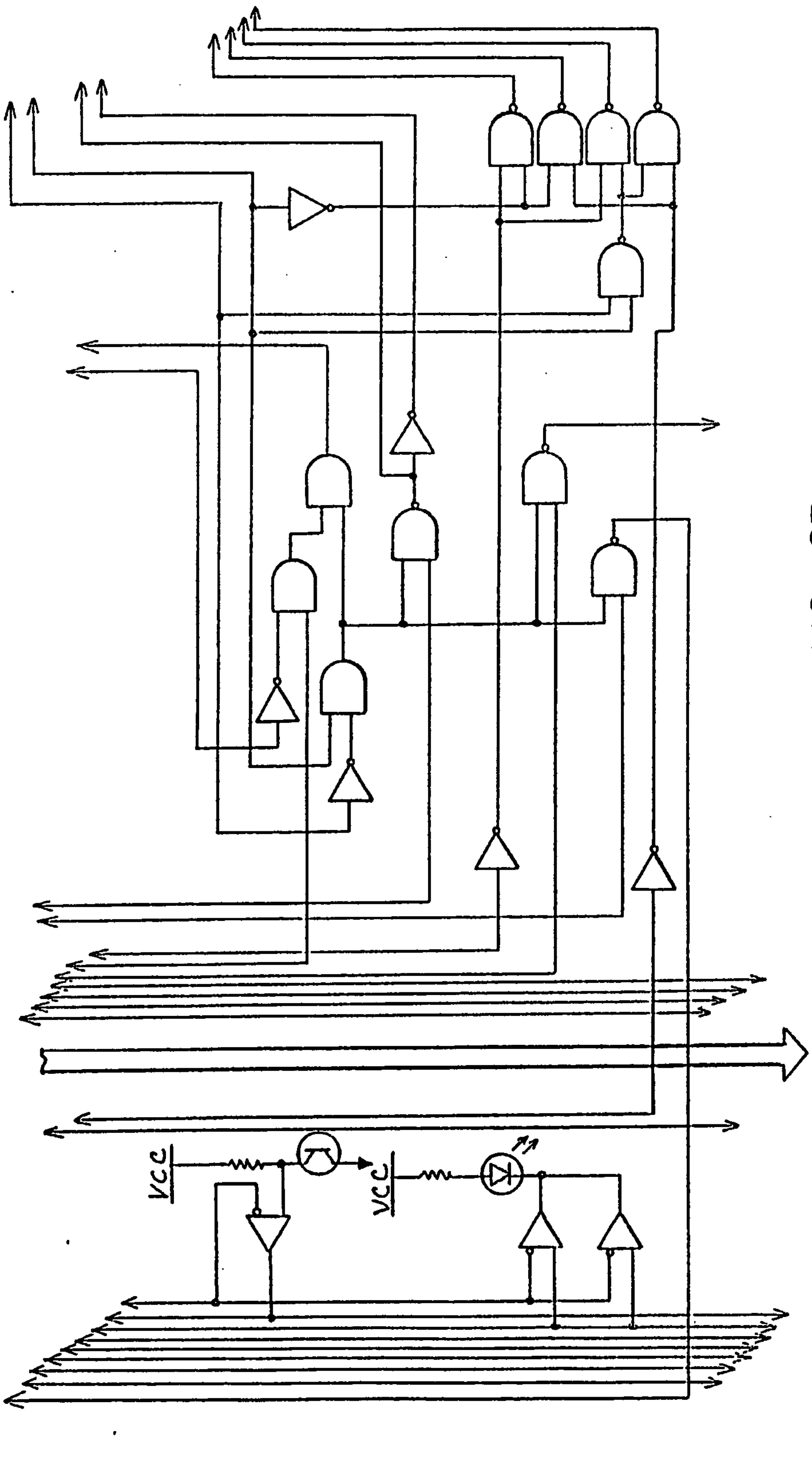

FIG - 8B

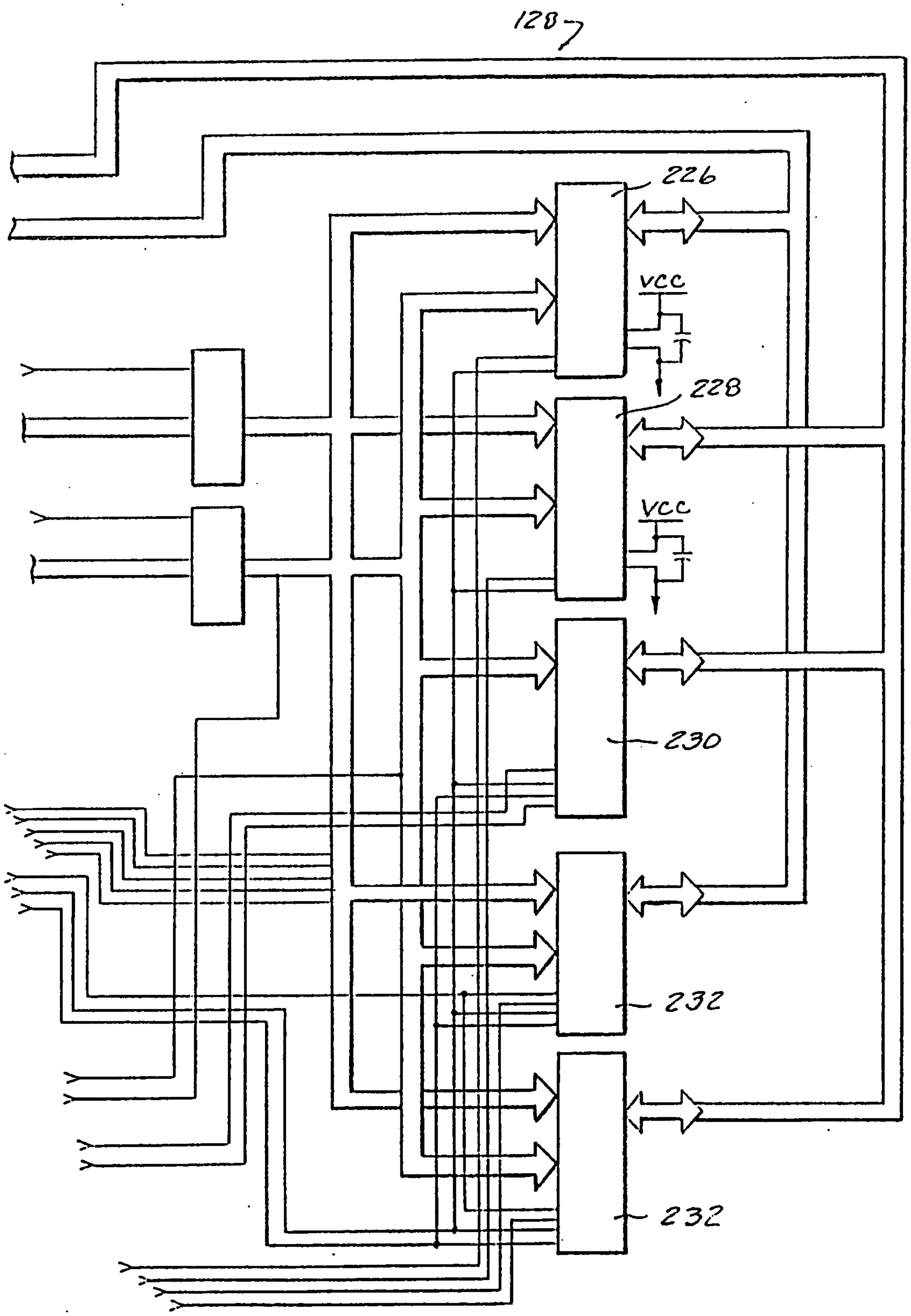

FIG - 8C

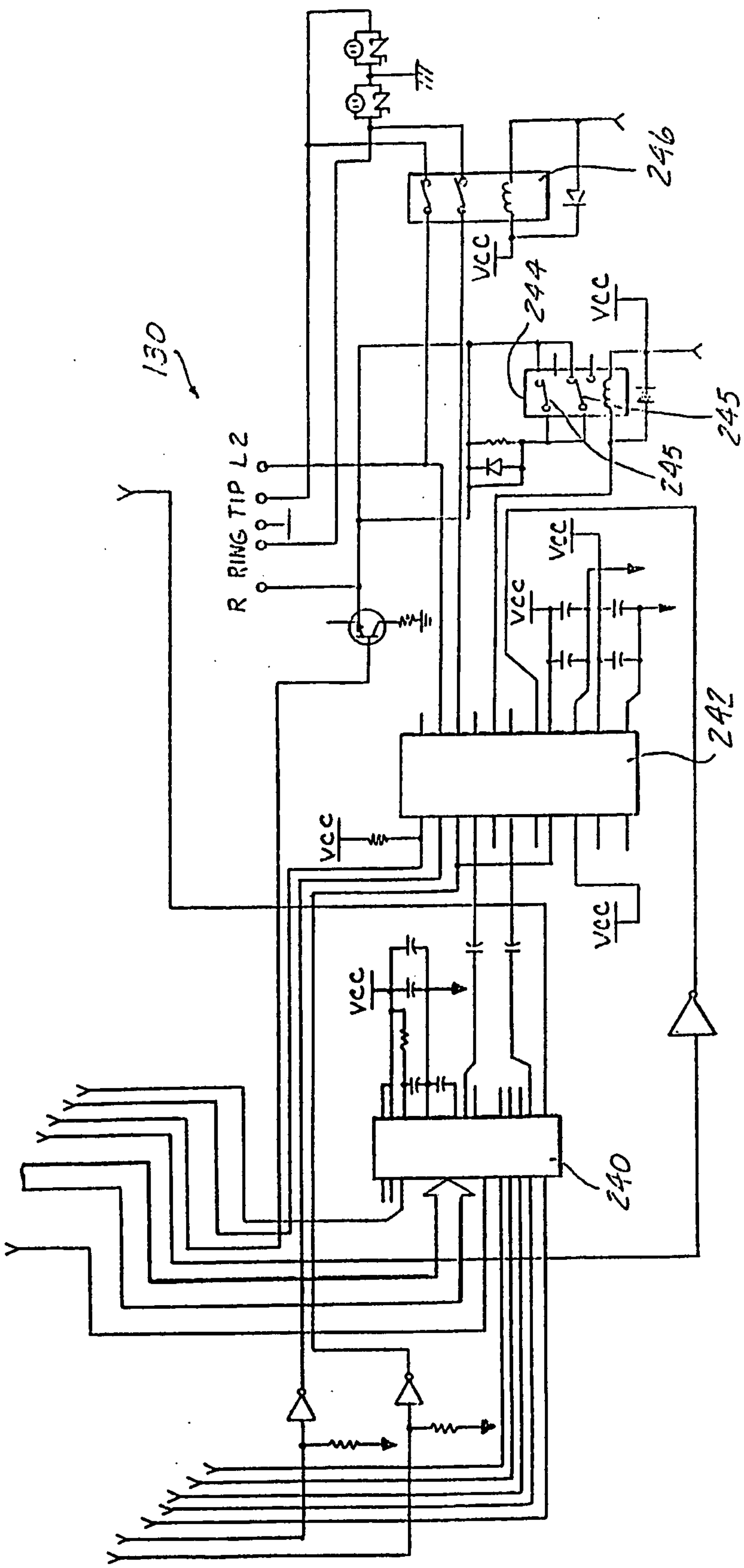

FIG-9

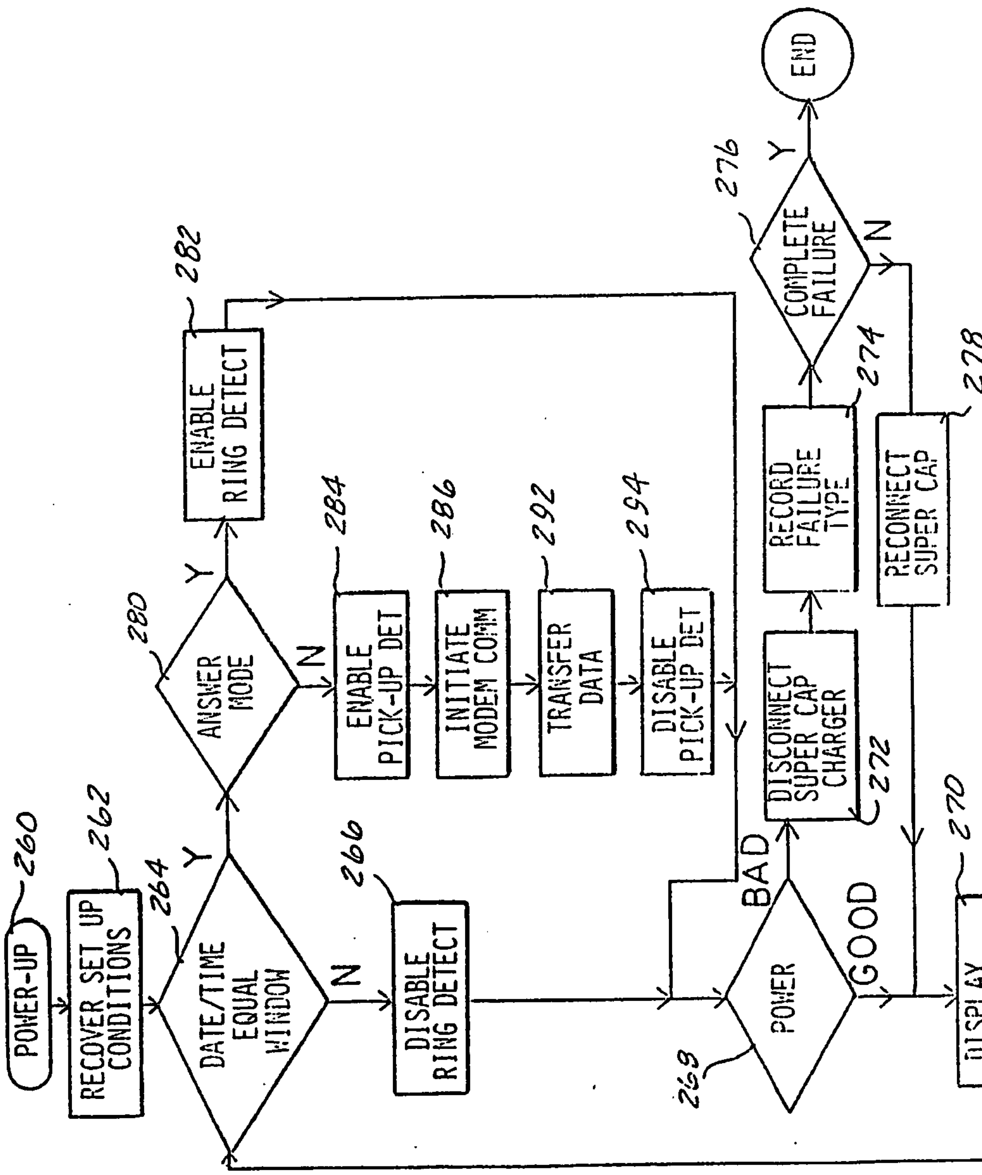
POWER-UP
260
RECOVER SET UP CONDITIONS
262
264
DATE/TIME EQUAL WINDOW
Y
N
DISABLE RING DETECT
266
280
ANSWER MODE
Y
N
ENABLE RING DETECT
282
ENABLE PICK-UP DET
284
INITIATE MODEM COMM
286
TRANSFER DATA
292
DISABLE PICK-UP DET
294
268
POWER
BAD
GOOD
DISCONNECT SUPER CAP CHARGER
272
RECORD FAILURE TYPE
274
COMPLETE FAILURE
276
Y
N
END
RECONNECT SUPER CAP
278
DISPLAY DATA
270

FIG -10

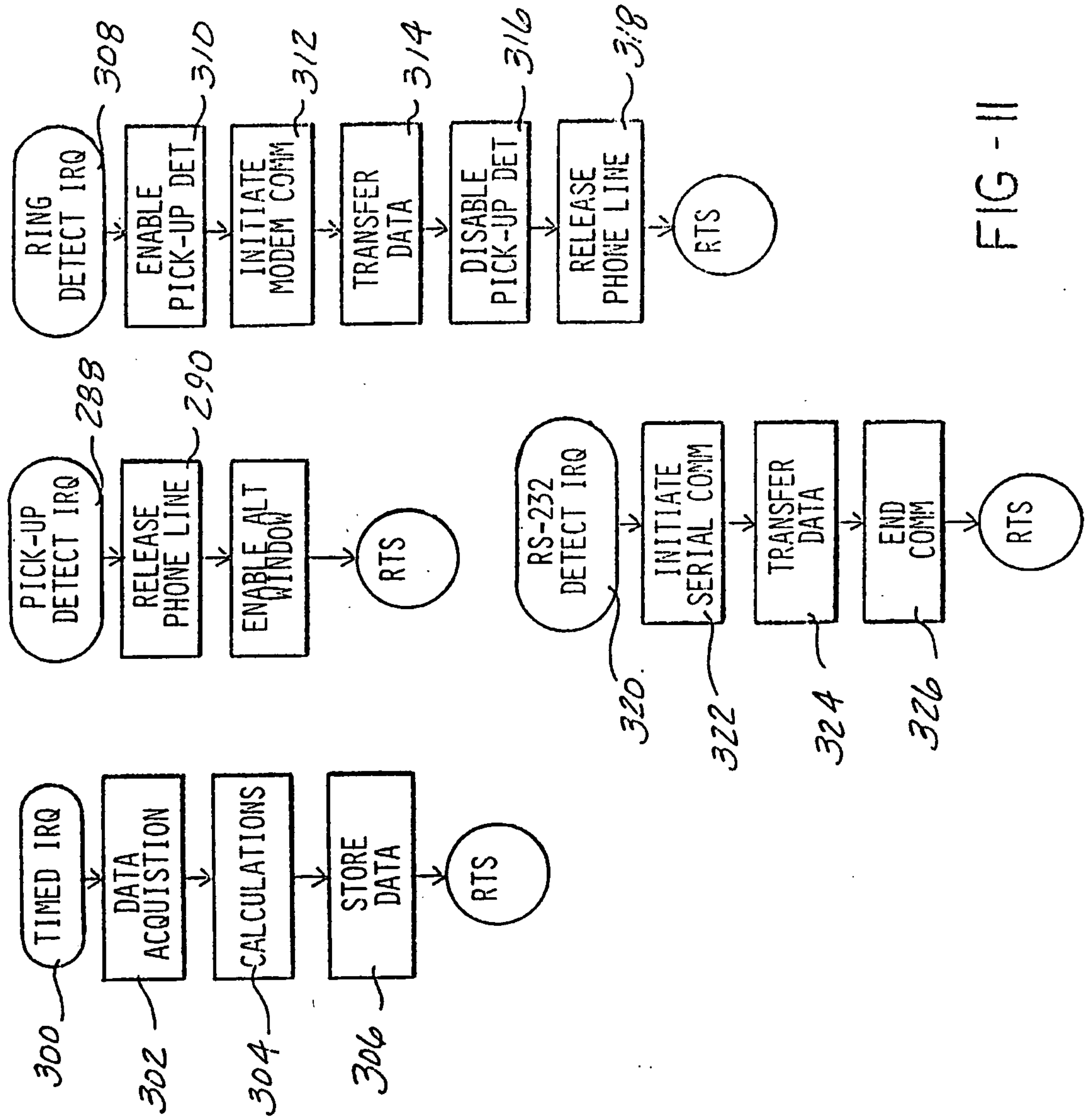
RING DETECT IRQ
308
ENABLE PICK-UP DET
310
INITIATE MODEM COMM
312
TRANSFER DATA
314
DISABLE PICK-UP DET
316
RELEASE PHONE LINE
318
RTS
PICK-UP DETECT IRQ
288
RELEASE PHONE LINE
290
ENABLE ALT WINDOW
RTS
RS-232 DETECT IRQ
320
INITIATE SERIAL COMM
322
TRANSFER DATA
324
END COMM
326
RTS
TIMED IRQ
300
DATA ACQUISTION
302
CALCULATIONS
304
STORE DATA
306
RTS

FIG - 11

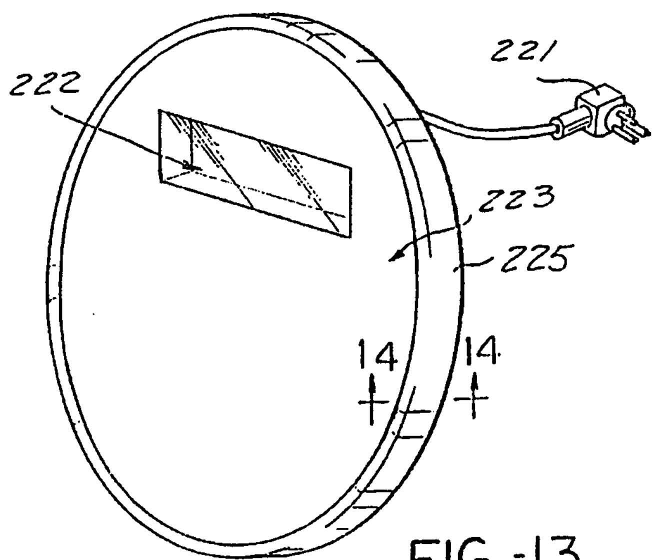

FIG -13

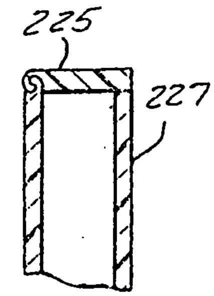

FIG 14

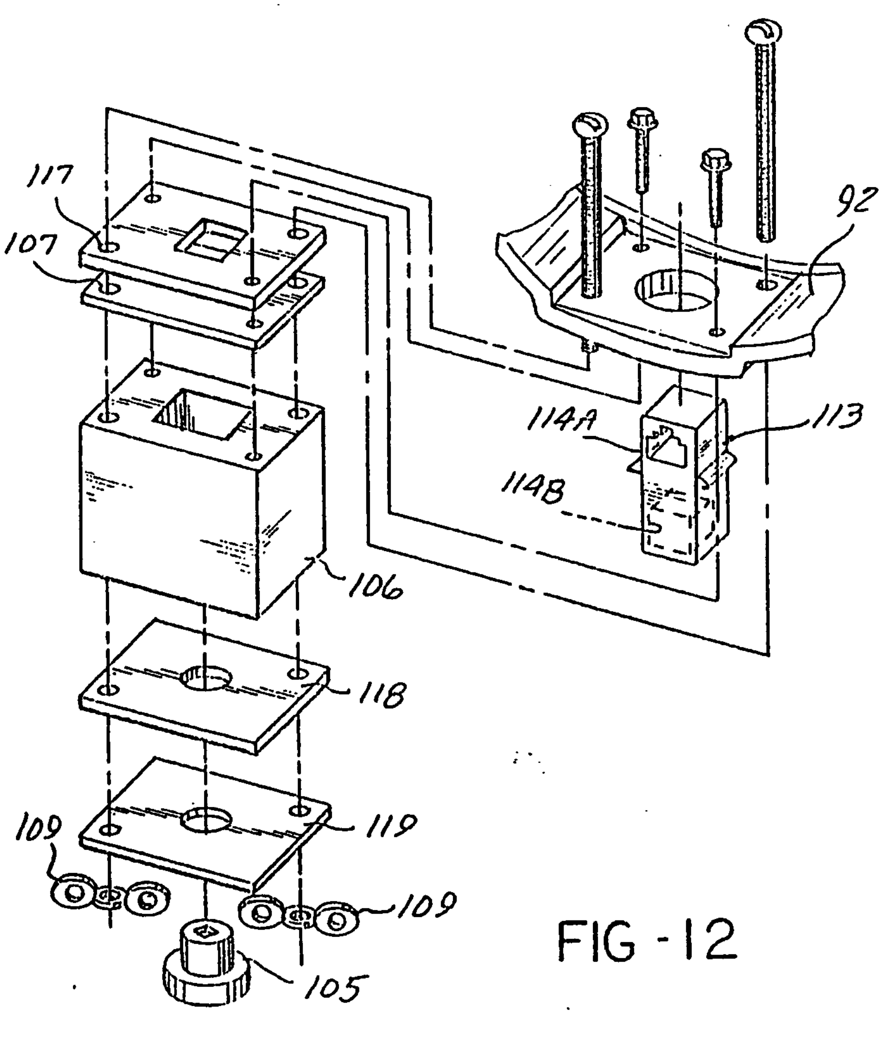

FIG -12

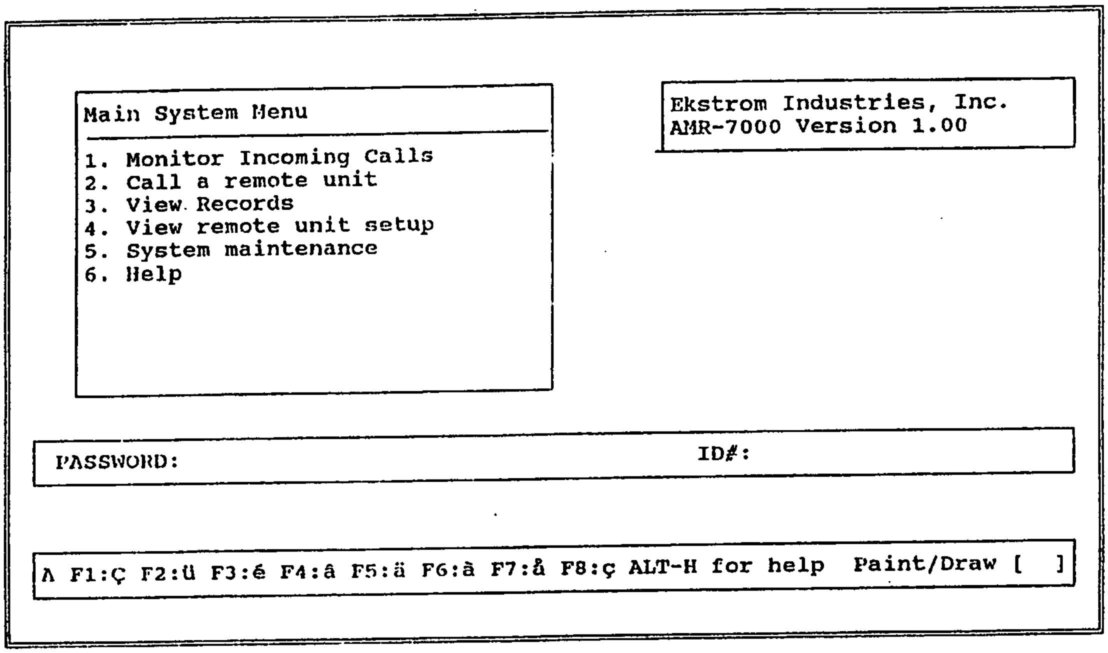
Main System Menu
1. Monitor Incoming Calls
2. Call a remote unit
3. View Records
4. View remote unit setup
5. System maintenance
6. Help
Ekstrom Industries, Inc.
AMR-7000 Version 1.00
PASSWORD:
ID#:
Λ F1:Ç F2:ü F3:é F4:â F5:ä F6:à F7:å F8:ç ALT-H for help Paint/Draw [ ]

FIG. 16

AMR-7000 Select View Main menu Shutdown Dos HELP

System Loading

Idle 78%
CPU 98%
Disk 7%

System Response

Response ********************* 34m
Turn ********************* 145mS
Thpt ********************* 65mS

Select view

#1 CALLING UNIT STATUS

Telephone#... 345-1234
Id# ... AMR-7000
Date ... 09-30-92
Time ... 13:51:34

OK
OK
OK
OK

NEXT: Use [Ctrl«],[Ctrl»]

#528 CALLING UNIT STATUS

Telephone #... 763-4657
Id# ... AMR-7000
Date ... 09-30-92
Time ... 13:50:59

OK
OK
OK

NEXT: Use [Ctrl«],[Ctrl»]

CURRENT
Time 13:50:59
Date 09-30-92

Total Number of Calls IN ...345
Total Number of Calls OUT ...012

1.2 loaded

A F1:Ç F2:ü F3:é F4:â F5:ä F6:à F7:å F8:ç ALT-H for help Paint/Draw [ ]

FIG. 17

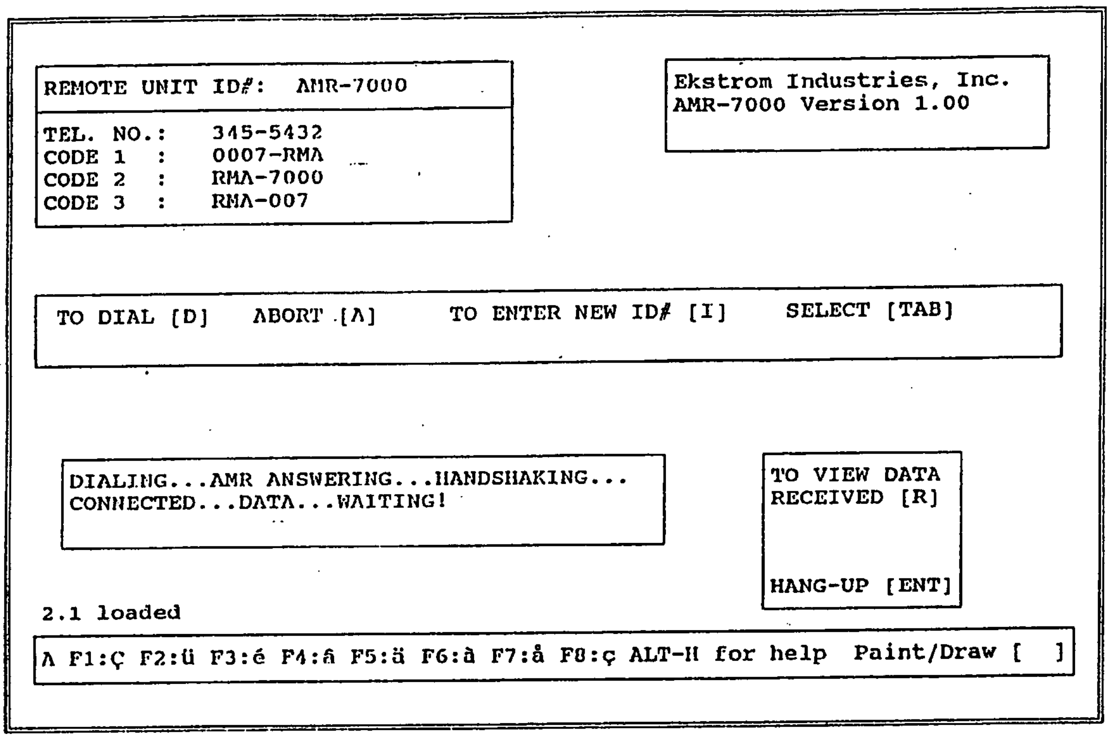
REMOTE UNIT ID#: AMR-7000
TEL. NO.: 345-5432
CODE 1 : 0007-RMA
CODE 2 : RMA-7000
CODE 3 : RMA-007
Ekstrom Industries, Inc.
AMR-7000 Version 1.00
TO DIAL [D] ABORT [A] TO ENTER NEW ID# [I] SELECT [TAB]
DIALING...AMR ANSWERING...HANDSHAKING...
CONNECTED...DATA...WAITING!
TO VIEW DATA RECEIVED [R]
HANG-UP [ENT]
2.1 loaded
Λ F1:Ç F2:ü F3:é F4:â F5:ä F6:à F7:å F8:ç ALT-H for help Paint/Draw [ ]

FIG. 18

TO VIEW LAST MONTHS RECORDS [L] · PREVIOUS MENU [ESC]

REMOTE UNIT ID#: AMR-7000
CURRENT READINGS:
Instantaneous-
Volts L1: 123.02V
L2: 117.12V
Amps L1: 12.90A
L2: 126.96A
KW :
KVAR :
PF :

1107 Lambs Ln.
Dallas
Accumulated since last reading-
KWH :____,____,346,678.231
KVAR :____,____,____,____.____
PF : 98.12
Max. Volts : 131.21V
Min. Volts : 099.12V
\# of Outages: 5
Out. Duration: 21.75Hrs

TO DATE ACCUMULATED READINGS
KWH : ____,_54,276,457.123
KVAR :
PF : 99.01
\#Outages : 23
Outages Dur.: 25.12

Access Window Programming-
Call-OUT
Next Window: 10-30-92 13:30:00
Code1: Code3:
Code2:

A F1:Ç F2:ü F3:é F4:â F5:ä F6:à F7:å F8:ç ALT-H for help Paint/Draw [ ]

FIG. 19

```
TO VIEW LAST SETUP [L]        PREVIOUS MENU [ESC]             OFF LINE

REMOTE UNIT ID#: AMR-7000                    Location: 1107 Lambs Ln.
Code1:   0007-RMA                                      Dallas
Code2:   RMA-7000                            Name: John T. Shincovich
Code3:   RMA-0007
                                             CALL IN/OUT:  OUT

ACCESS WINDOW: 30th Day
Time:  13:55:00                                        KW     : YES/ONLY
Window Size: 5 Min.                                    KVAR   : YES
Alternate1: 24 Hrs.  Size: 5 Min.                      KVA    : YES
Alternate2: 48 Hrs.  Size: 5 Min.                      PF     : YES
Demand1 ON: 06:30  OFF: 08:45
Demand2 ON:        OFF:                                CONTROL OUT: ON/OFF
Demand3 ON: 18:00  OFF: 21:00
Tamper Switch: YES/NO
Line Quality Monitoring: YES/NO              Supervisory Number: 1-800-234-1234
                                                  Alternate    :  -    -345-1232

  4.0 loaded

A F1:Ç F2:ü F3:é F4:â F5:ä F6:à F7:å F8:ç ALT-H for help  Paint/Draw [  ]
```

FIG. 20

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/01552

A. CLASSIFICATION OF SUBJECT MATTER
IPC(5) :H04M 11/00.
US CL : 379/106.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)

U.S. : 379/104-107, 102; 340/870.01-870.03, 870.29; 307/66; 361/663-665; 439/135,517; 324/74, 142, 141, 103, 103R; 364/483.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 5,122,735 (PORTER et al) 16 June 1992, see entire document.	36-52
X ----- Y	US, A, 4,902,965 (BRODRUG et al) 20 February 1990, see entire document.	1-5,8,9,11 ----- 6,7,10,12-35,53-59
Y	EP, A, 0,416,569 (BAXTER et al) 13 March 1991, see page7, lines 7-13.	6,7
Y	US, A, 4,394,540 (WILLIS et al) 19 July 1983, see abstract, col. 3 lines 1-9.	10
Y	CA, A, 2,049,206 (MCCLELLAND et al) 18 February 1992, see entire document.	12-35,53-59

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be part of particular relevance
"E" earlier document published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 JULY 1994	JUL 19 1994
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer WING F. CHAN Telephone No. (703) 305-4750

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/01552

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 5,025,470 (THORNBOROUGH et al) 18 June 1991, see abstract.	17
Y	US, A, 4,803,632 (FREW et al) 07 February 1989, see abstract, fig. 1.	18,57

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/01552

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark n Protest ☐ The additional search fees were accompanied by the applicant's protest.
☐ No protest accompanied the payment of additional search fees.

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

1. This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

2. Group I, Claims 1-35, 53-59, drawn to an electricity telemetry system for remote reading of electric meter, classified in Class 379, subclass 106.

Group II, Claims 36-52, drawn to a method for metering an electrical power supply having first and second parameters exhibiting a periodic cycle phase relationship, classified in Class 340, subclass 870.02.

3. The inventions listed as Groups I, II do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Inventions I and II are related as combination and subcombination. Inventions in this relationship are distinct if it can be shown that (1) the combination as claimed does not require the particulars of the subcombination as claimed for patentability, and (2) that the subcombination has utility by itself or in other combinations. In the instant case, the combination as claimed does not require the particulars of the subcombination as claimed because the Group I claims only broadly require an electricity metering means in general and does not require the specific method steps of the Group II claims, as evidenced by claim 1.